

HST SM-3B

Hingepin Survey

MLI Survey

Reboost HST Motion Analysis

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JSC/SX3

<http://sx-isag.jsc.nasa.gov>



Electronic Still Camera

- RMS video surveys are time consuming, low resolution, difficult to review and examine; the picture always goes bad during the good parts.
- Digital Camera System (DCS) 760 is the best way to get a comprehensive set of detailed images to the ground during a mission (Quickly? --No promises).
- DCS760 is similar to DCS460 which flew on STS-103, but better.
- Why not fly 2 cameras in case one fails,.... and so 2 crew members can shoot ESC surveys simultaneously!
.....(We can dream a little, can't we?!)

Crew comments from STS-103/SM-3A

- Pilot is the only one with time to spare
- Window time is very scarce
- Attempts at surveys were necessarily sporadic
- Difficult to keep track of what was surveyed
- Prioritize, Prioritize, Prioritize.

Priorities Conceptualized

(boiled down requirements)

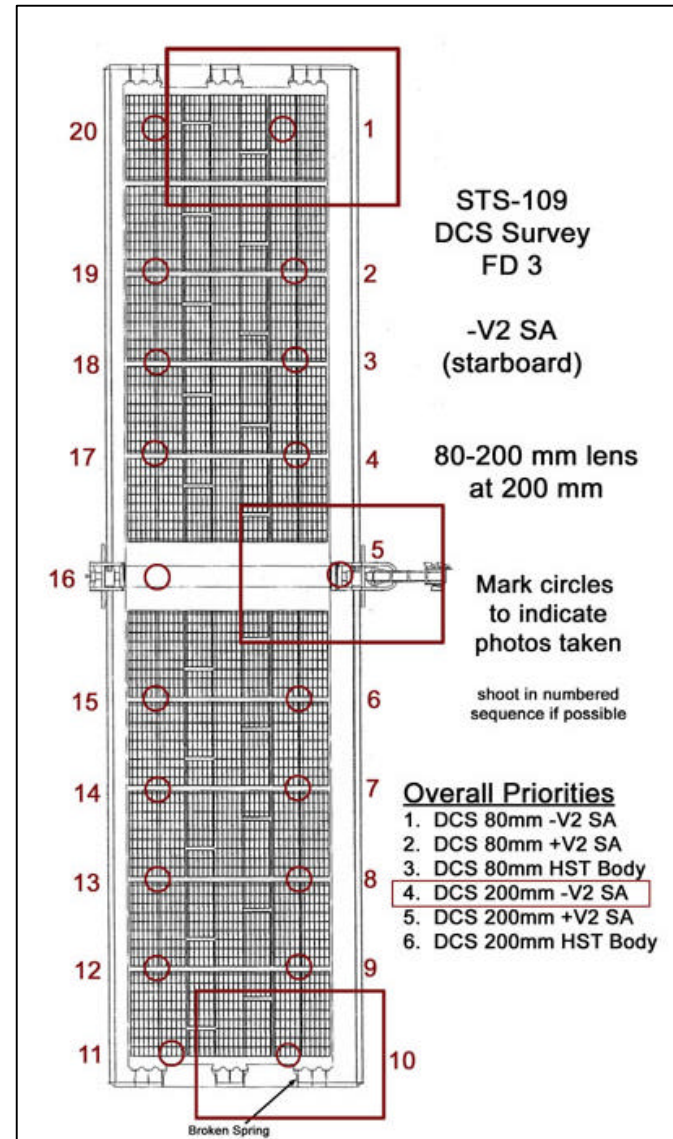
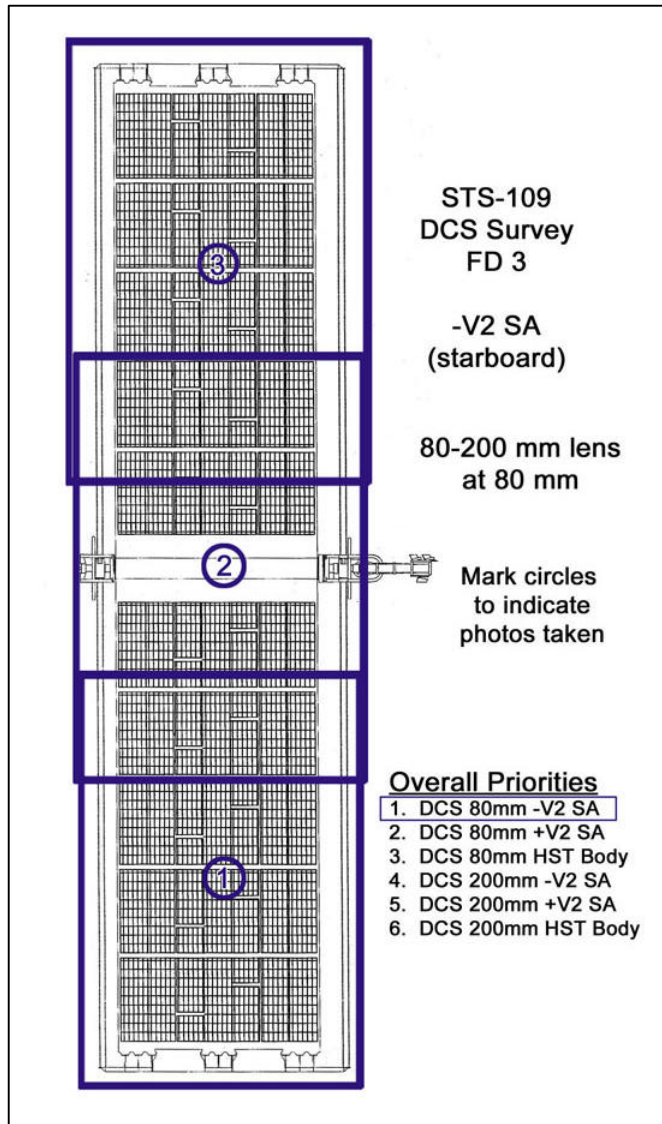
Targets

- Hingepins
 - -V2
 - +V2
- Aft Shroud Door Seals and Latches
- MLI

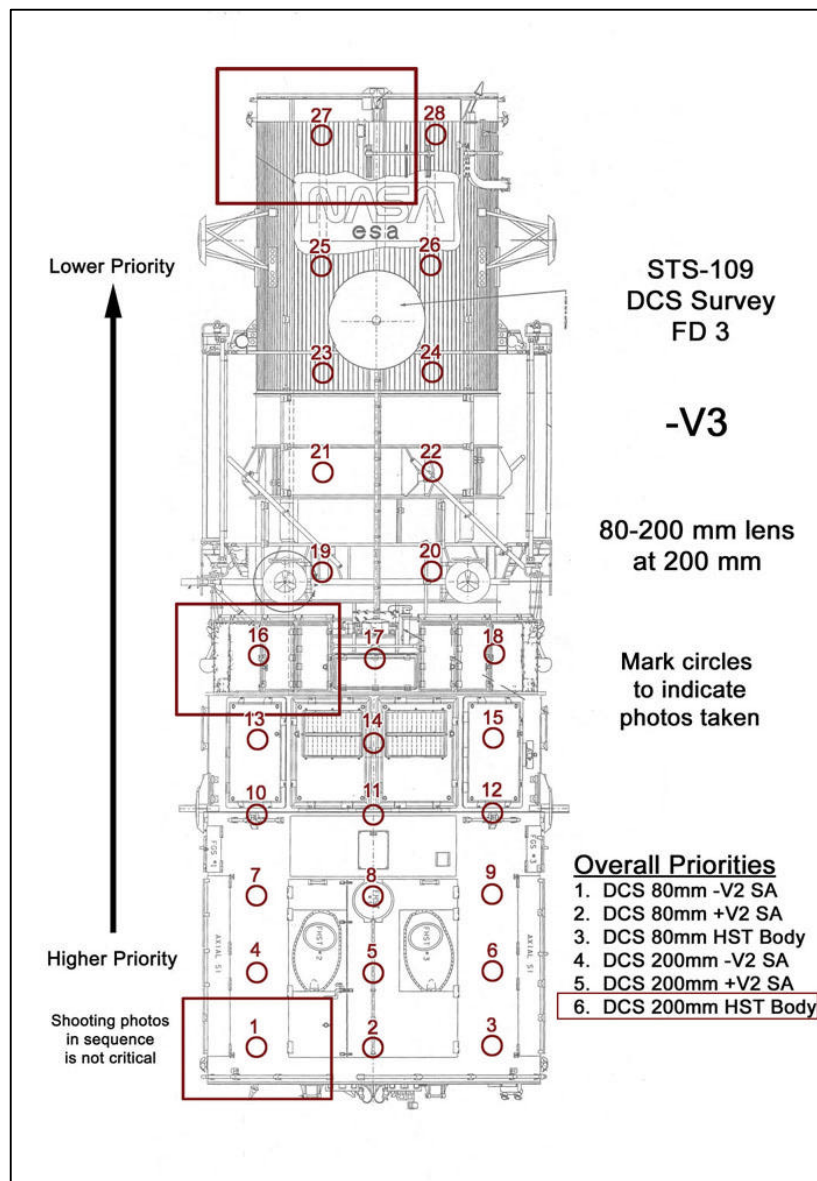
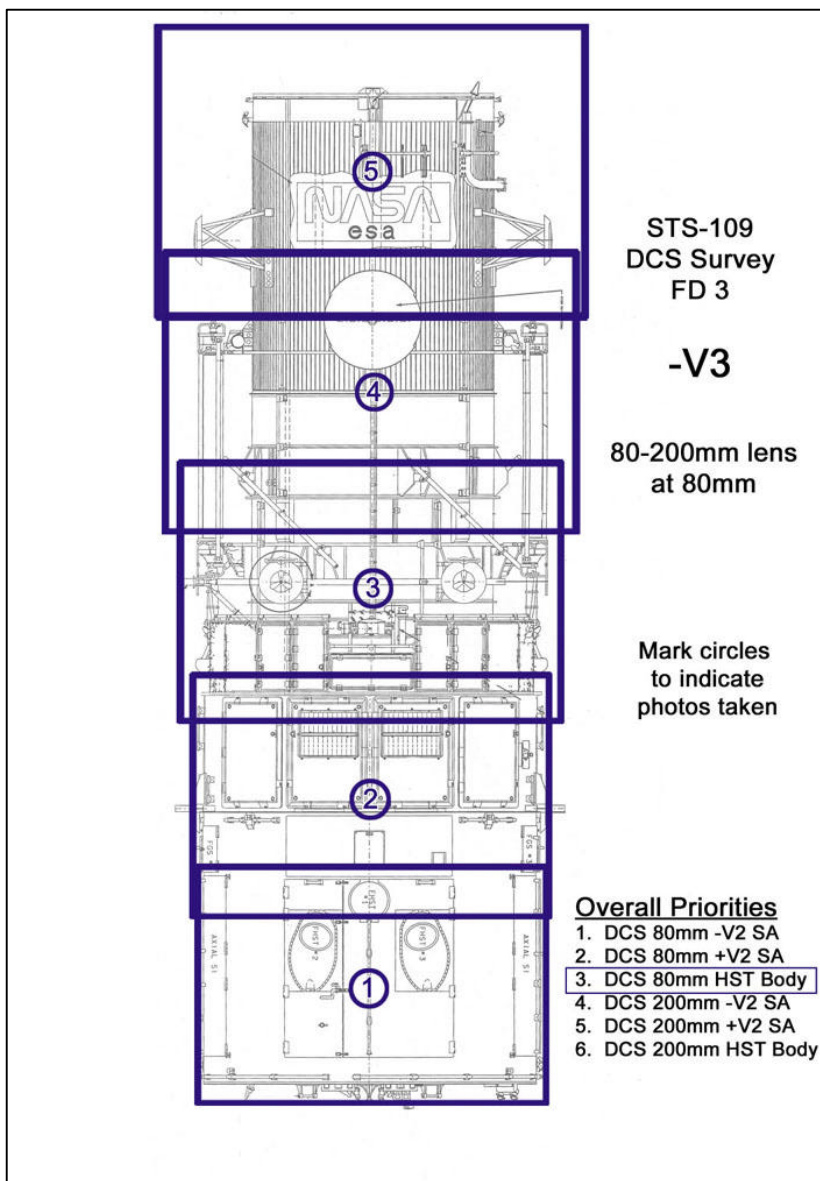
Magnification

- 80 mm lens
- 200 mm lens
- 400 mm lens (only by request)
- 800 mm (400mm lens with 2x doubler). Some -V2 door latches were successfully shot with this configuration (s109E5503-E5510).

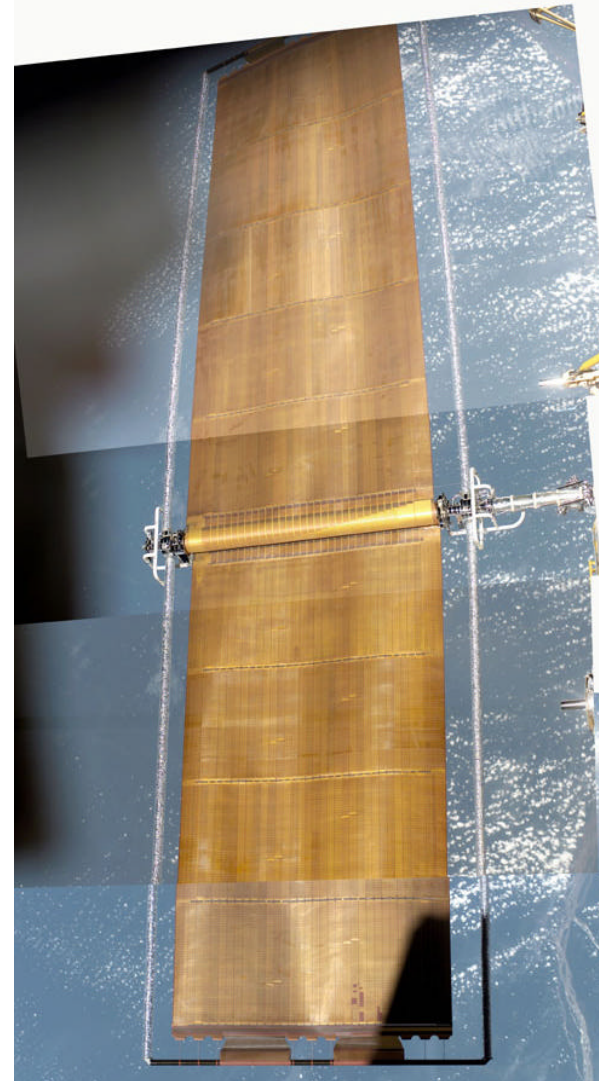
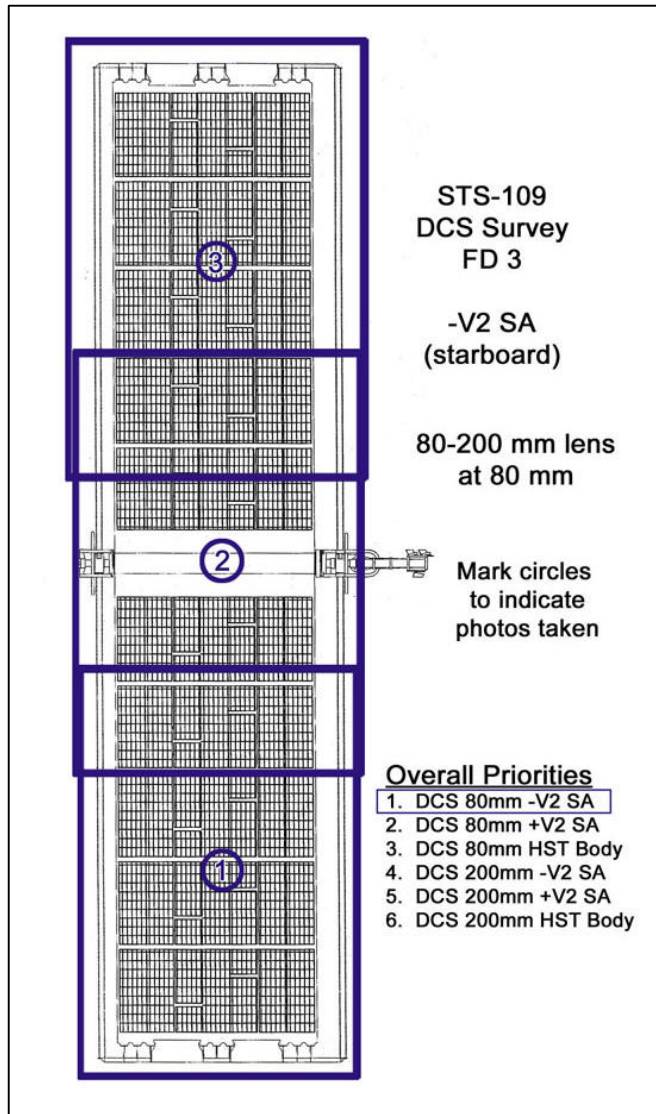
Priorities for Array Surveys



Photo/TV checklist diagrams for HST Body Survey



Array Surveys 80 mm



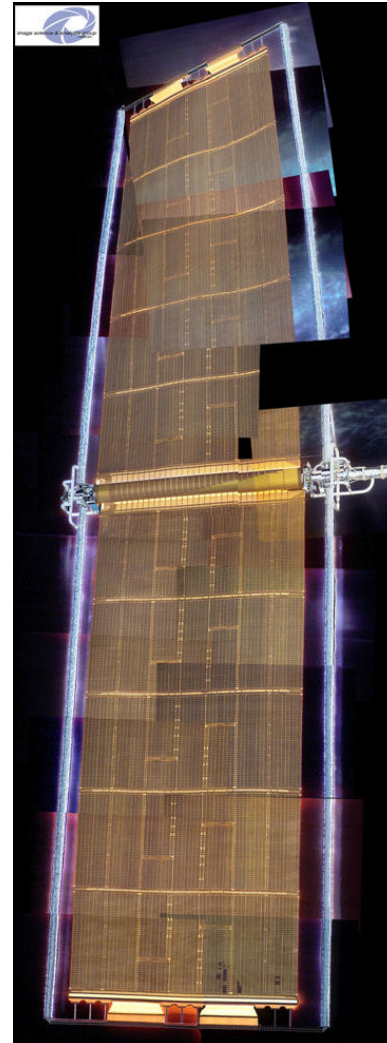
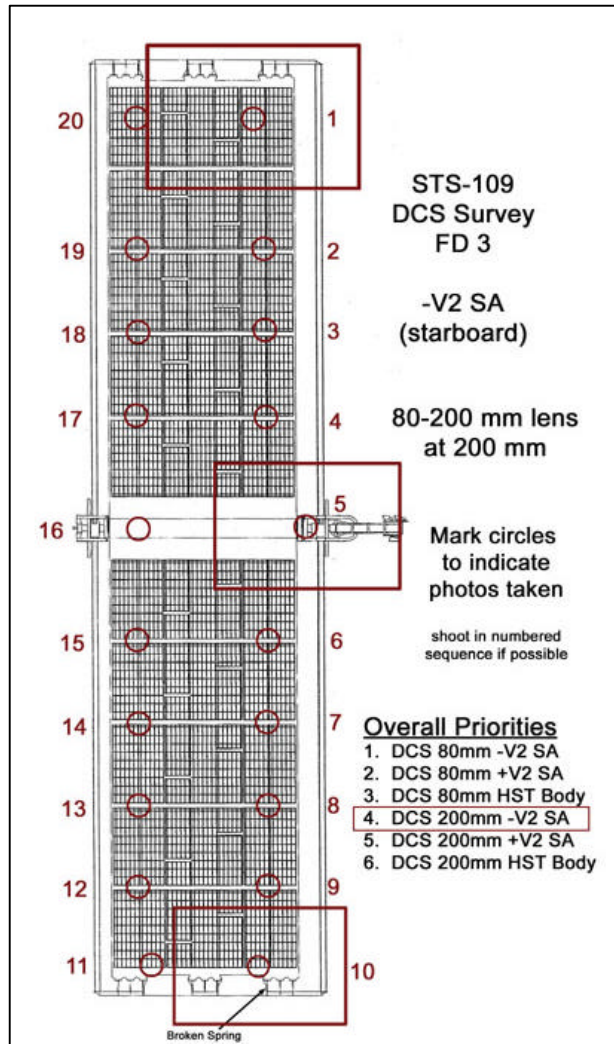
Preliminary Hingepin Report

80mm images only

Delivered 3/3/02 10:00am (end of Flight Day 3)

STS-109/ SM-3B					
-V2			+V2		
SPAs	Outboard	Inboard	SPAs	Inboard	Outboard
OBA GH / -AA	NO PIN	CAN'T SEE	OBA CD / +E	NO PIN	CAN'T SEE
-AA / -BB	NO PIN	NO PIN	+E / +D	NO PIN	NO PIN
-BB / -CC	NO PIN	NO PIN	+D / +C	NO PIN	NO PIN
-CC / -DD	NO PIN	NO PIN?	+C / +B	NO PIN	NO PIN
-DD / -EE	NO PIN	NO PIN	+B / +A	NO PIN	NO PIN
-EE / IBA		19.7	+A / IBA*	9.4	
IBA / -A		1.4	IBA / +EE*		4.9
-A / -B	NO PIN	NO PIN	+EE / +DD	NO PIN	NO PIN
-B / -C	NO PIN	NO PIN	+DD / +CC		20.6
-C / -D	NO PIN	NO PIN	+CC / +BB	NO PIN	NO PIN
-D / -E	NO PIN	NO PIN	+BB / +AA	NO PIN	NO PIN
-E / OBA EF	NO PIN	NO PIN	+AA / OBA AB	NO PIN	NO PIN
All measurements are in inches.					
*End of hingepins not visible. Therefore, this is a minimum length.					

Array Surveys 200mm



Final Hingepin Report

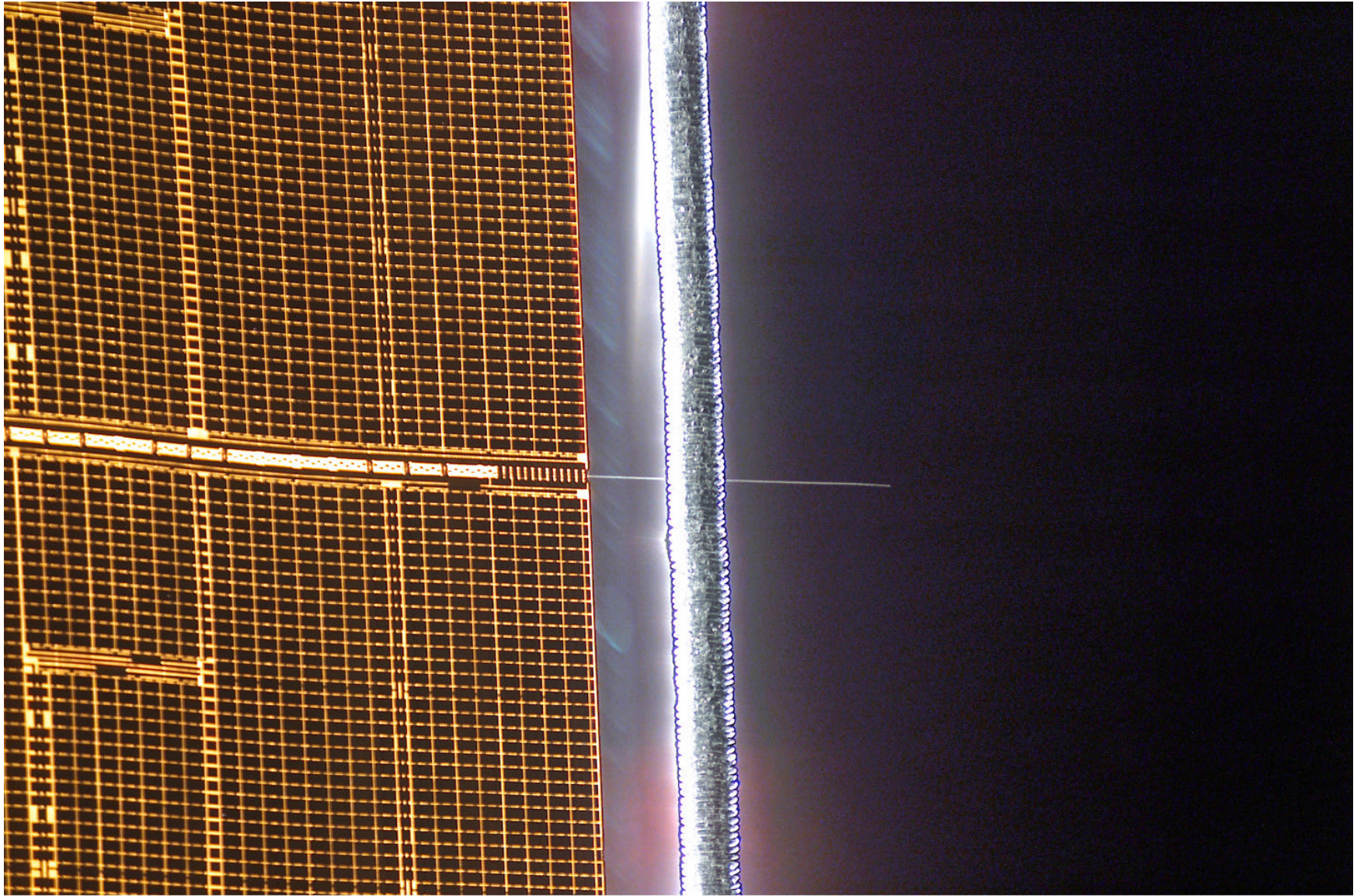
200mm images

Delivered 3/4/02 3:00am (-V2), 9:00am(+V2)

end of flight day 4

STS-109/ SM-3B					
-V2			+V2		
SPAs	Outboard	Inboard	SPAs	Inboard	Outboard
OBA GH / -AA	no pin	no pin	OBA CD / +E	no pin	no pin
-AA / -BB	no pin	1.3	+E / +D	no pin	no pin
-BB / -CC	no pin	0.4	+D / +C	no pin	no pin
-CC / -DD	no pin	3.7	+C / +B	no pin	no pin
-DD / -EE	no pin	no image	+B / +A	no pin	no pin
-EE / IBA	no pin	20.0	+A / IBA*	9.7	no pin
IBA / -A	no pin	1.4	IBA / +EE*	no pin	5.4
-A / -B	no pin	no pin	+EE / +DD	no pin	no pin
-B / -C	no pin	no pin	+DD / +CC	no pin	21.3
-C / -D	no pin	no pin	+CC / +BB	no pin	no pin
-D / -E	no pin	no pin	+BB / +AA	no pin	no pin
-E / OBA EF	no pin	no pin	+AA / OBA AB	no pin	no pin
All measurements are in inches.					
*The end of the pin was not visible (hidden by bistem) so this is a minimum length					

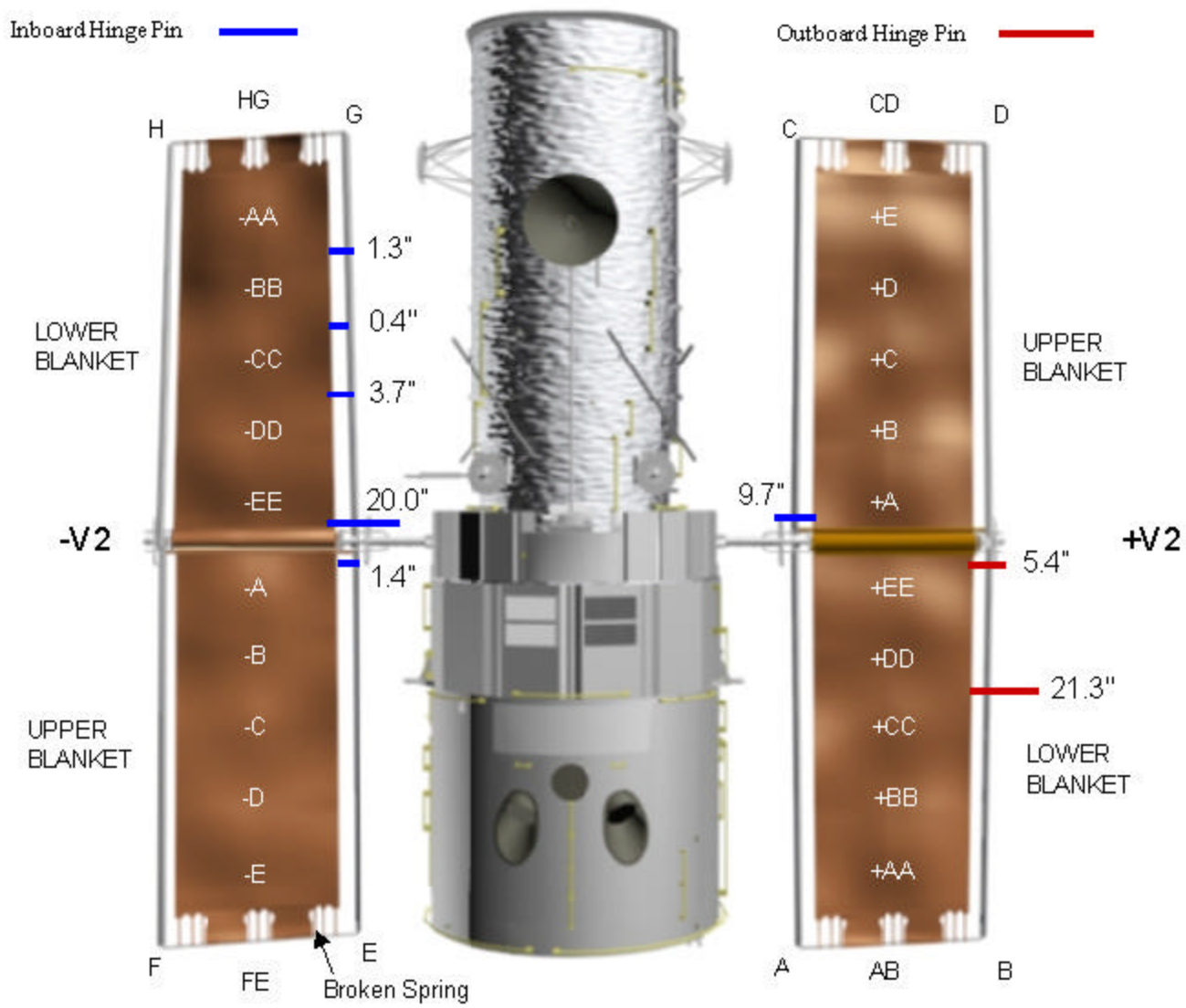
+V2 Pin Closeup (+DD/+CC, 21.3 inches)



S109E5216

Diagram of
hangepins

STS-109 SM-3B Hangepins



80mm HST Survey mosaics

http://sn-isag.jsc.nasa.gov/hubbleweb/sm3b/sm3b_dcs_survey.shtml



-V3 200mm Surveys

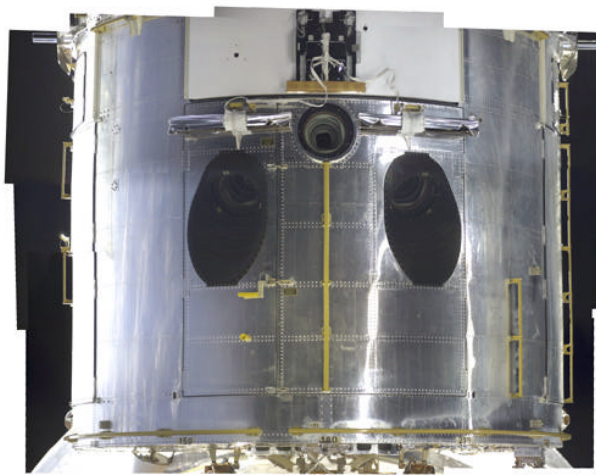
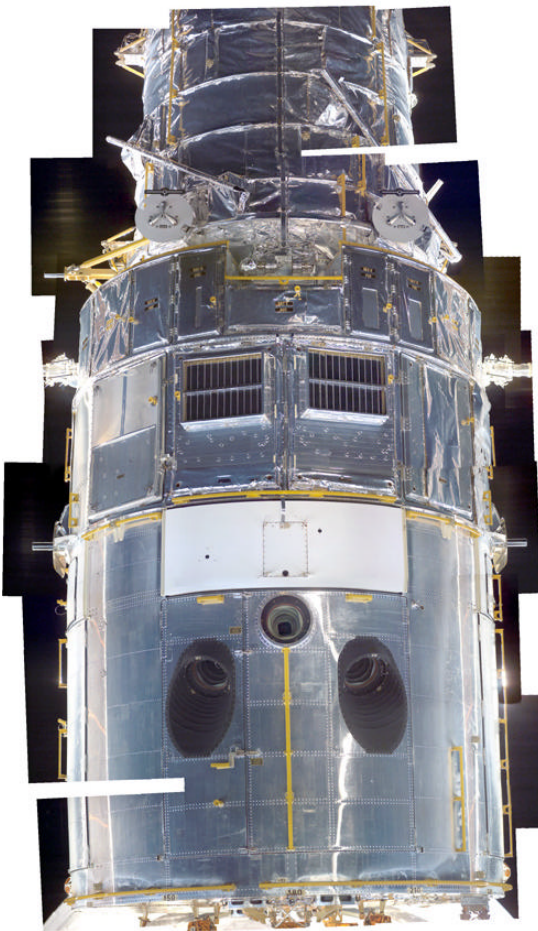
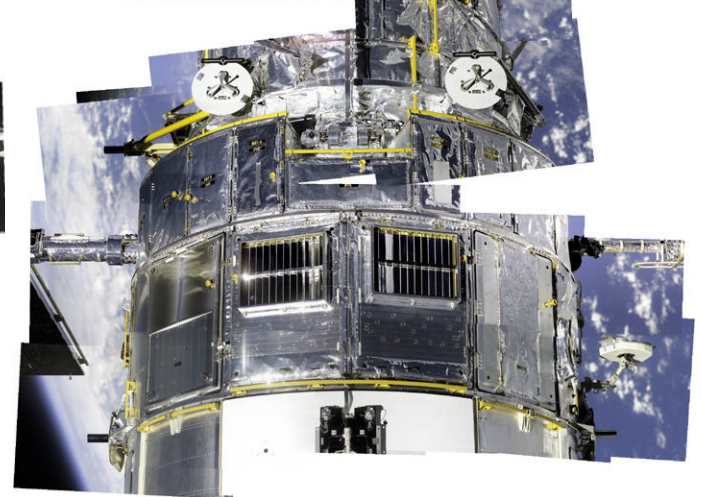
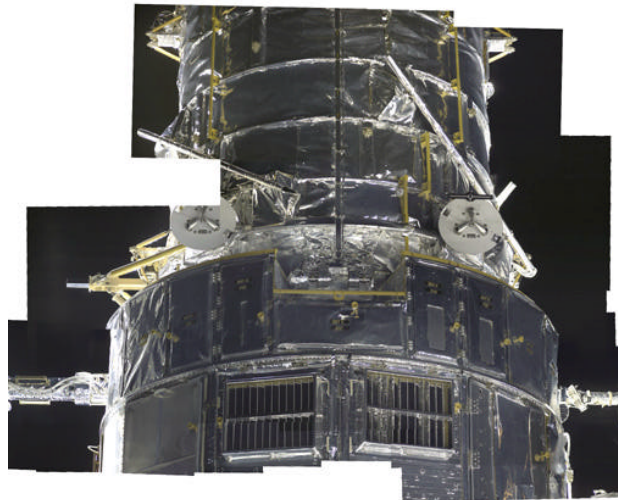
Survey 1

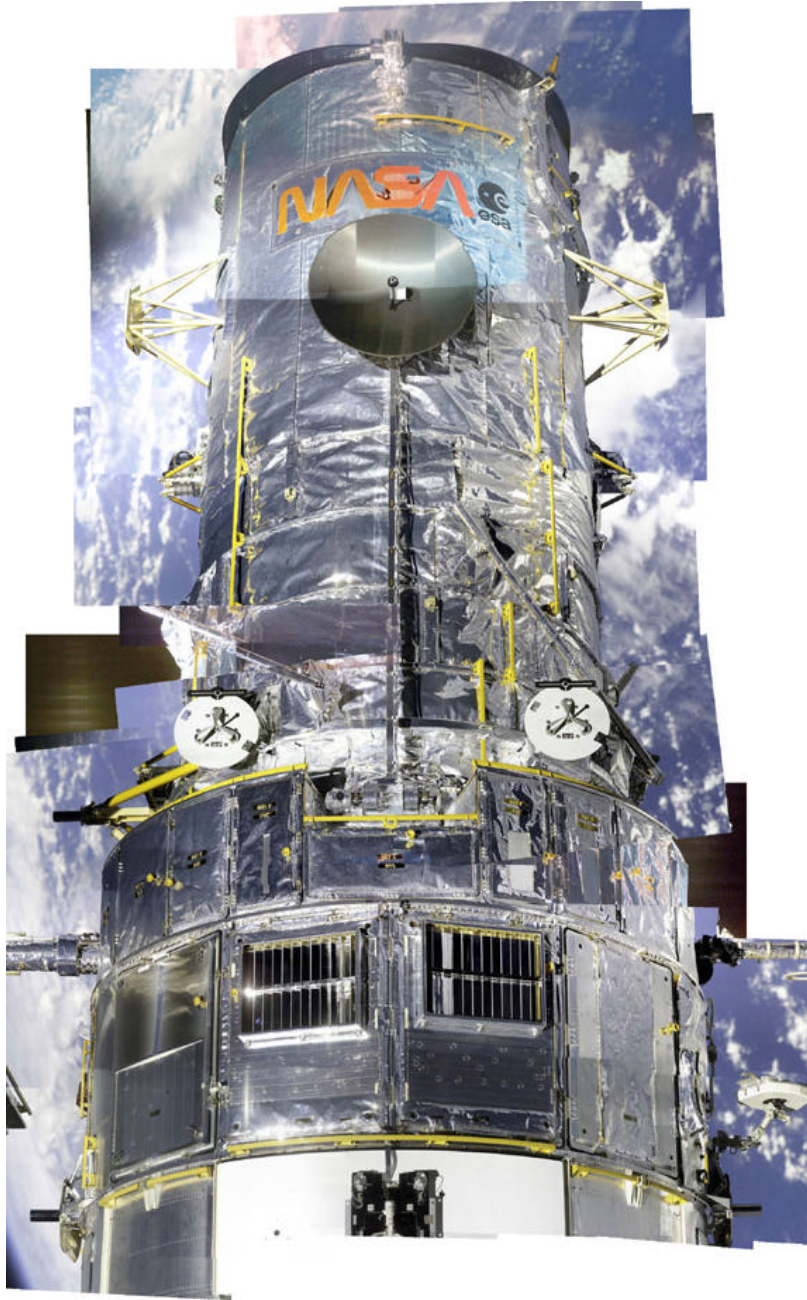


Survey 3



Survey 2

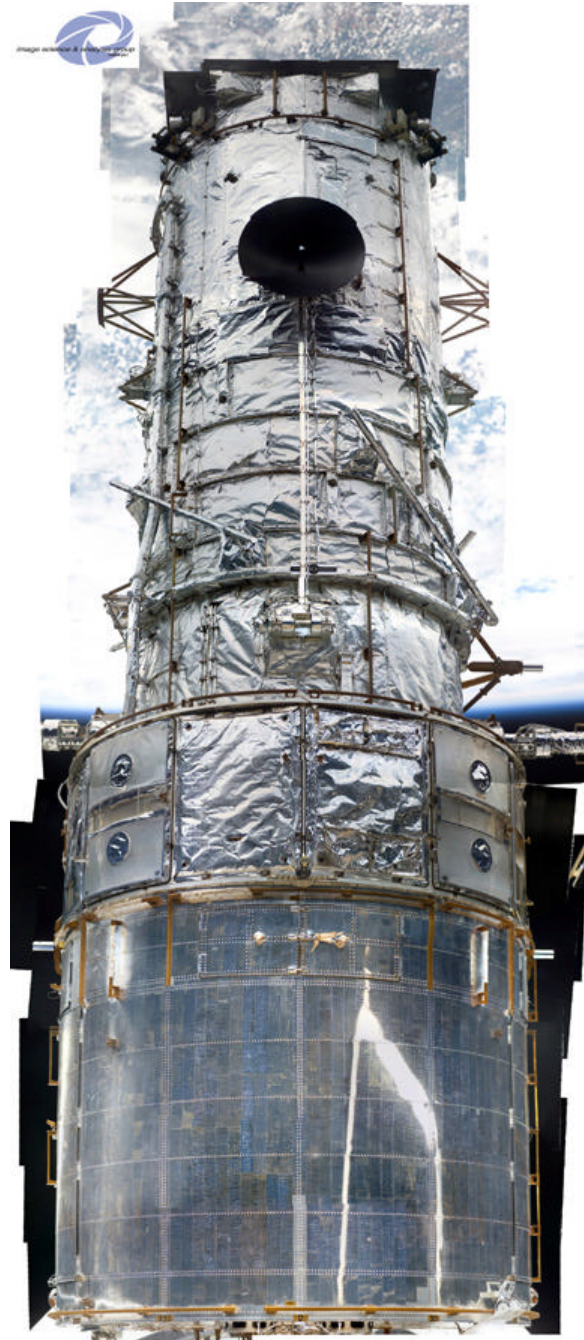




-V3 final composite

+V3 200mm

- Quality and Quantity of images was outstanding
- Excellent Lighting, Excellent Coverage
- 64 images taken with generous overlap
- 29 selected for MLI report

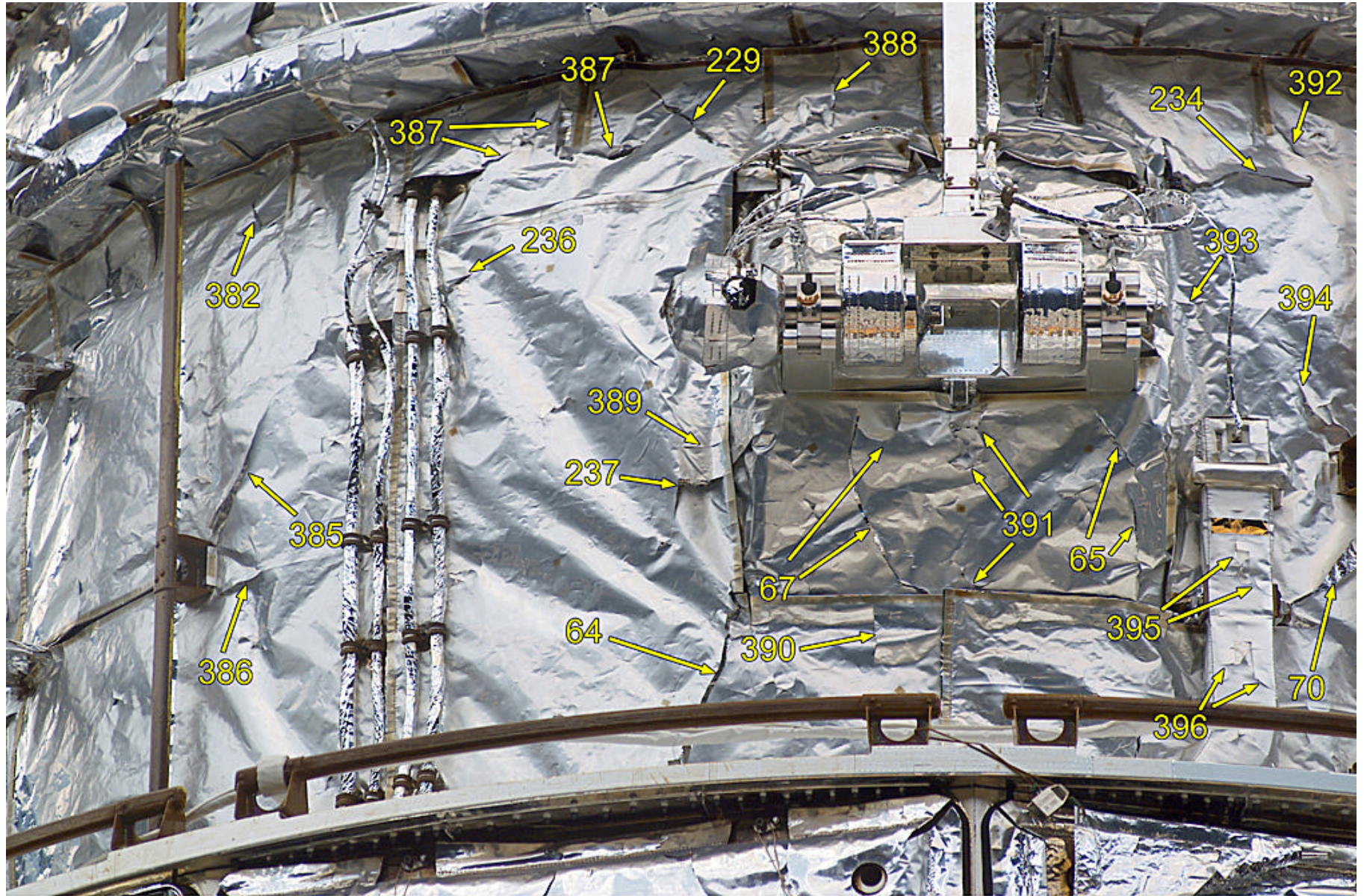


+V3 200mm



S109E5440

+V3 200mm



S109E5548

200mm –V2 Survey
incomplete

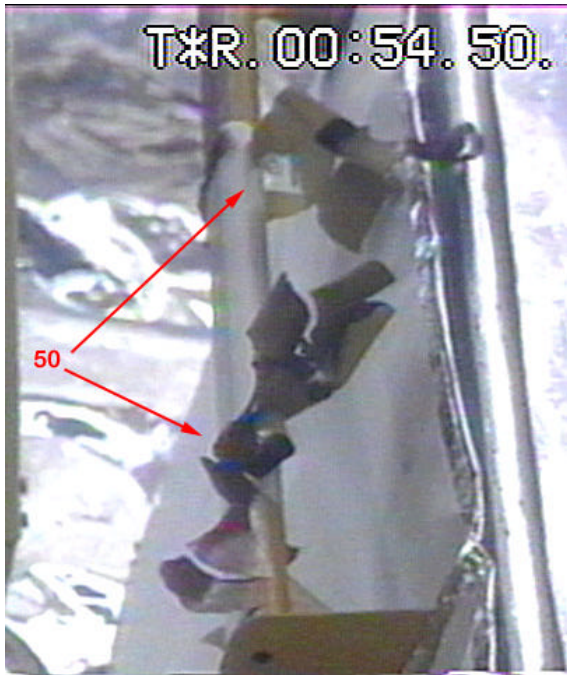


Supplemented with
80mm –V2 Survey

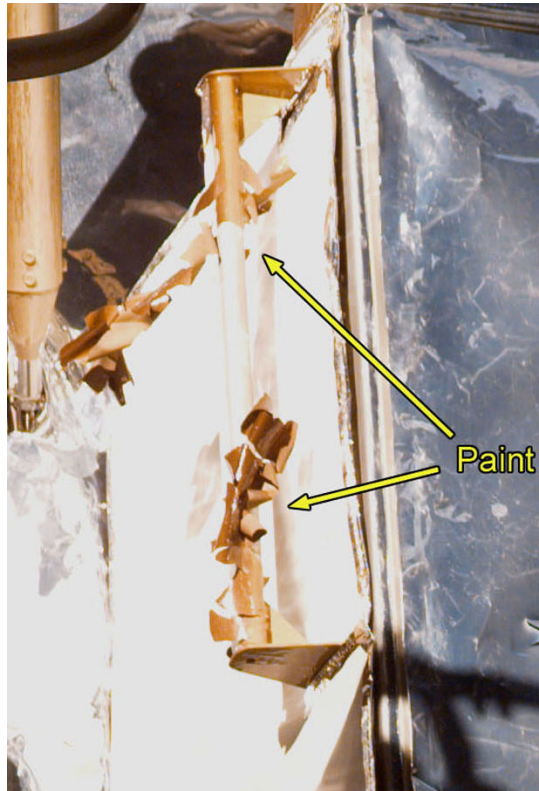


Bay A handrail

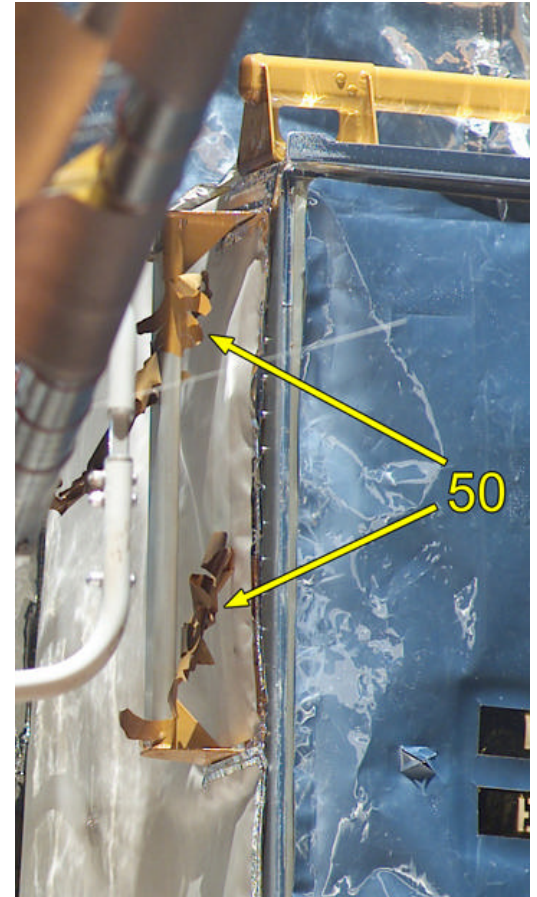
SM-2



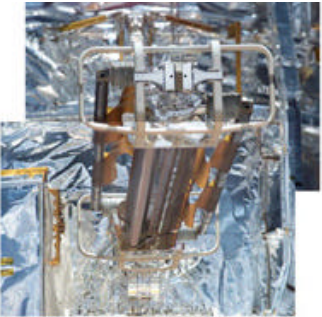
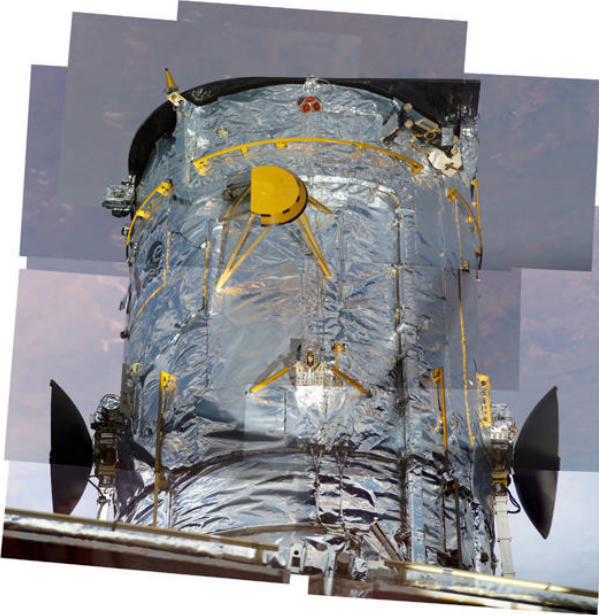
SM-3A



SM-3B

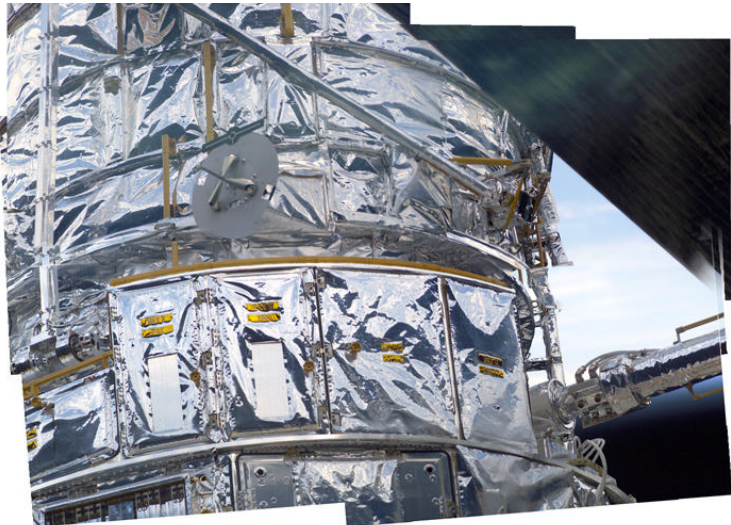
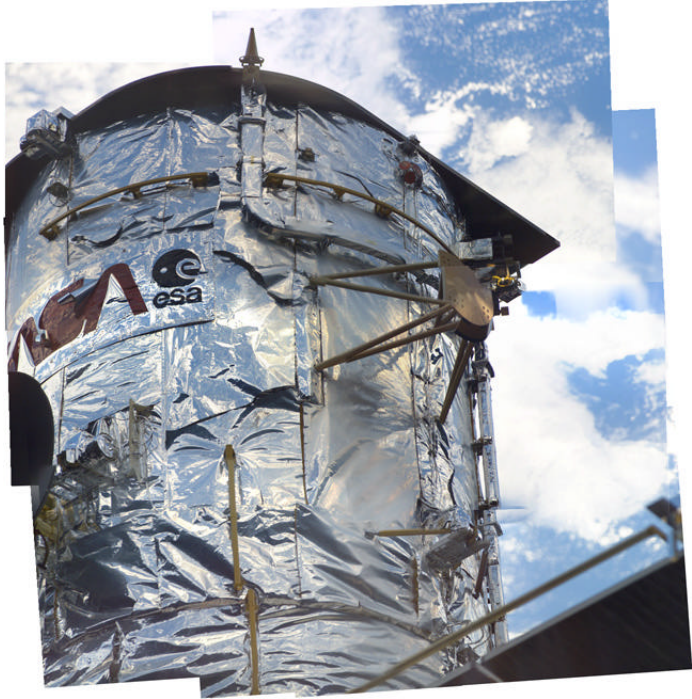


200mm + V2

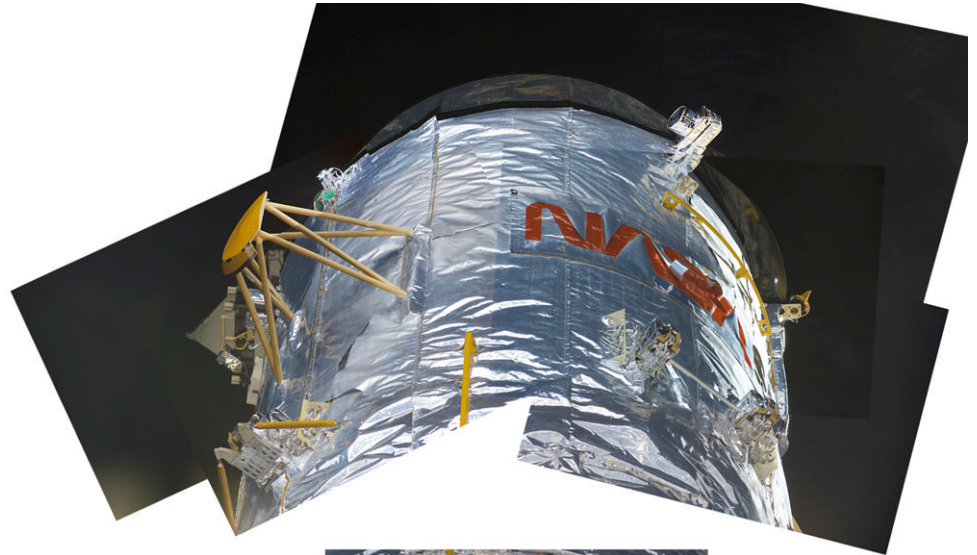


80 mm + V2

200mm -V3 to +V2 Rotation



-V2 / -V3 200mm
Taken during deploy



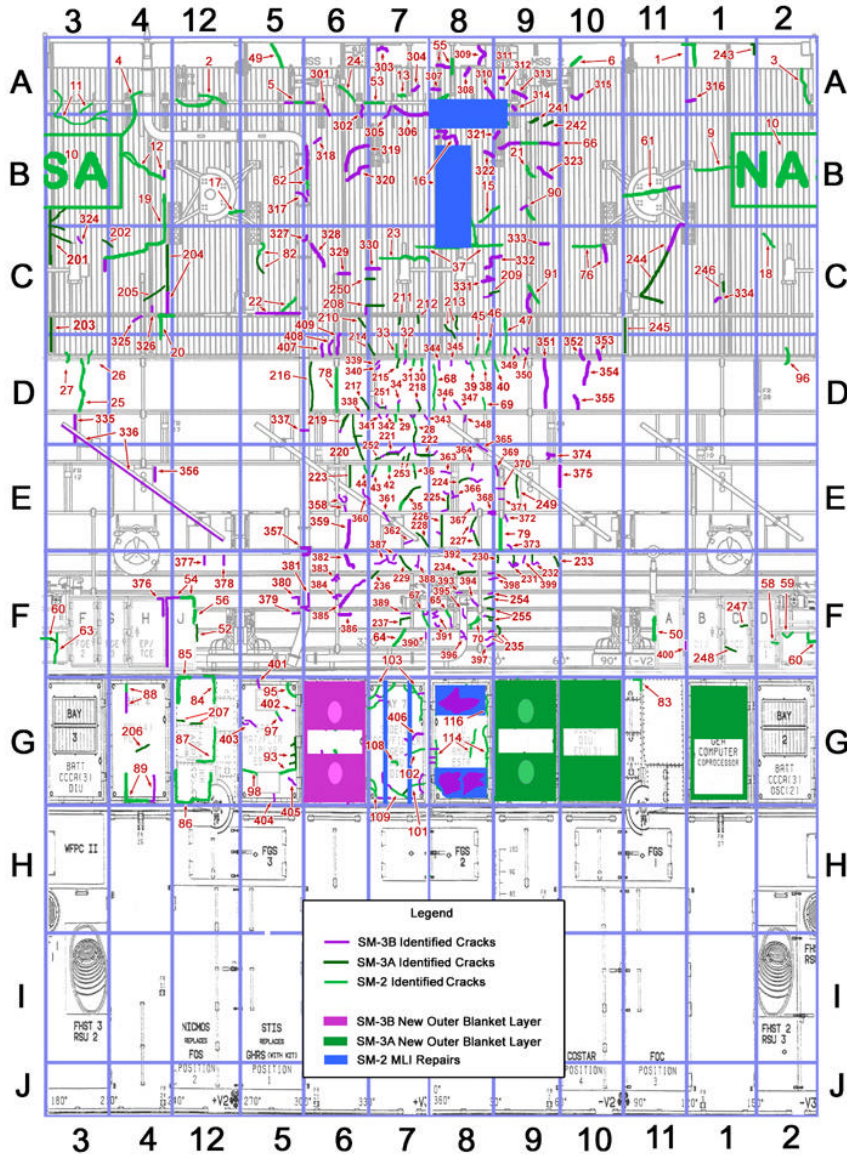
MLI Survey Results

- 109 New damage site identifications
- 38 old damage sites grew larger
- Majority of new damage on +V3 in areas not well imaged on SM-3A.

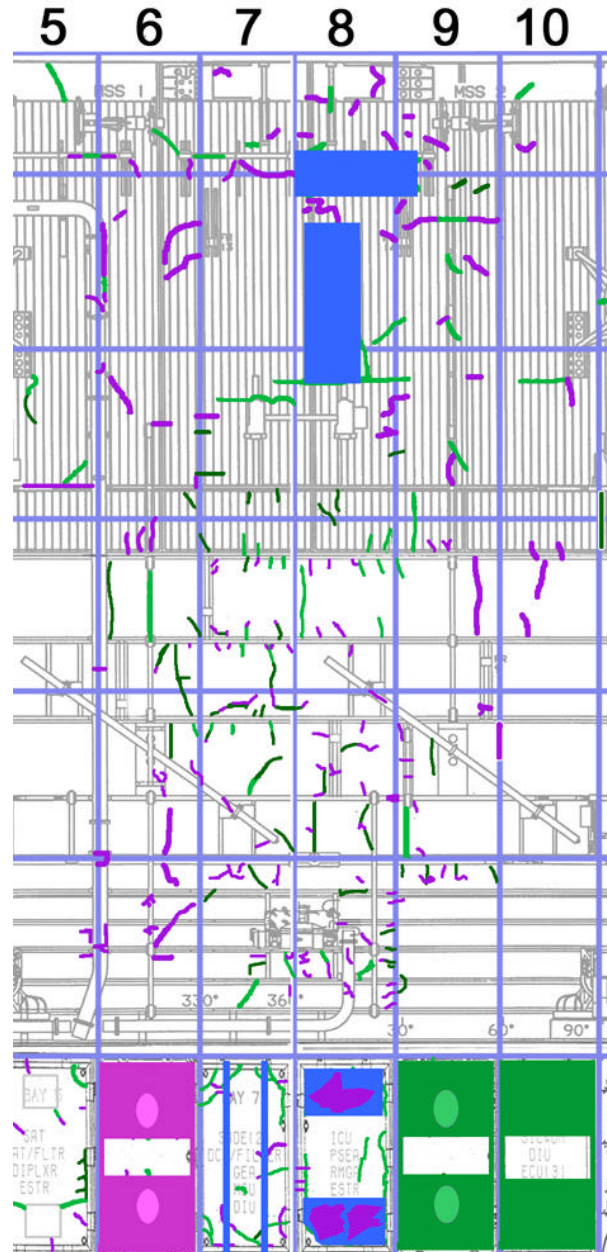


HST MLI Damage SM-3B

Figure 1
10/17/02

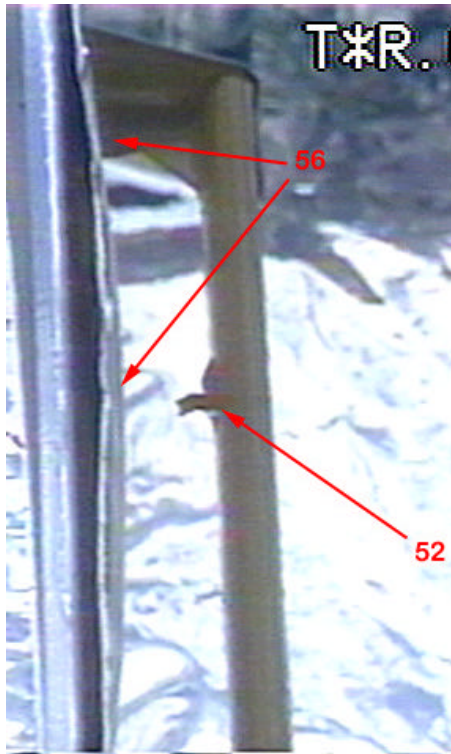


+V3 MLI damage

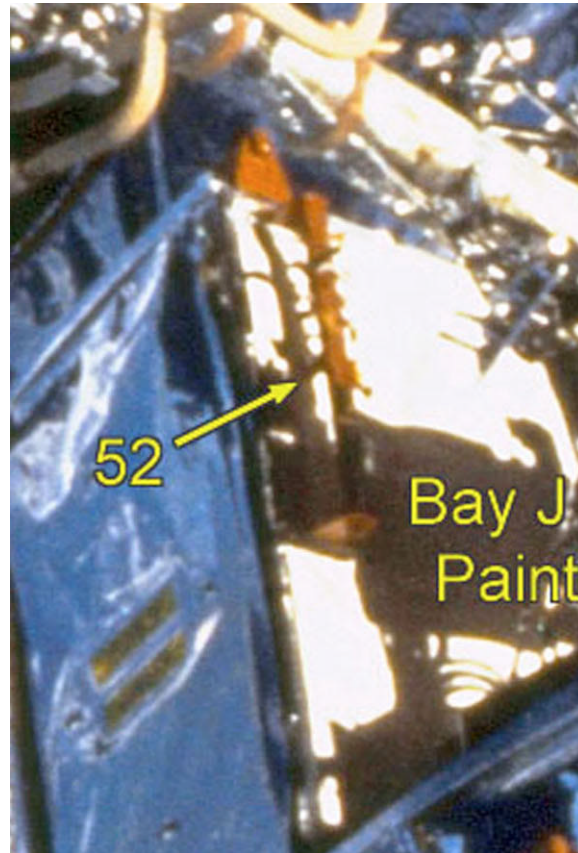


Bay J Handrail

SM-2



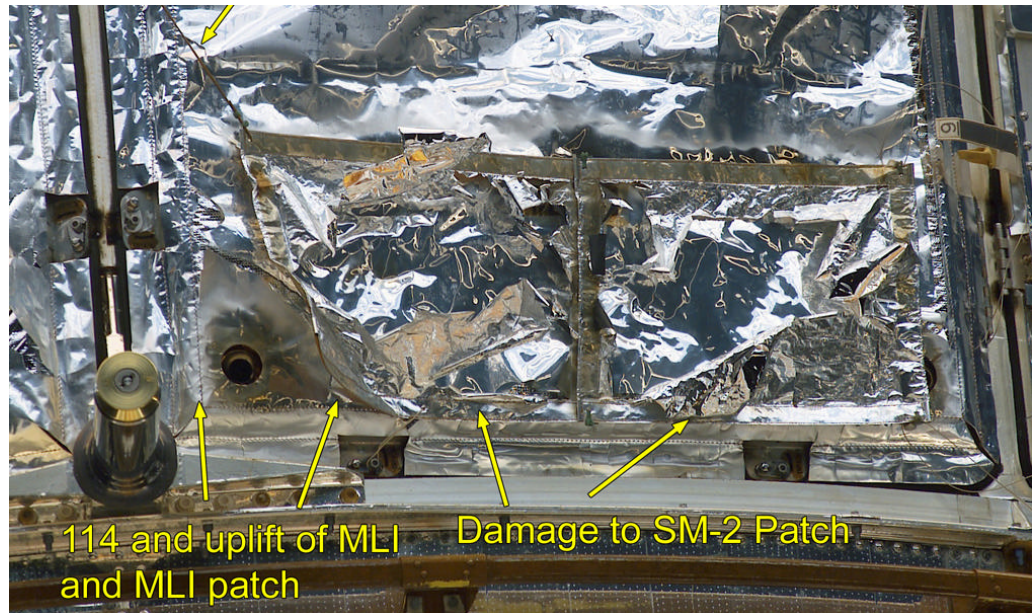
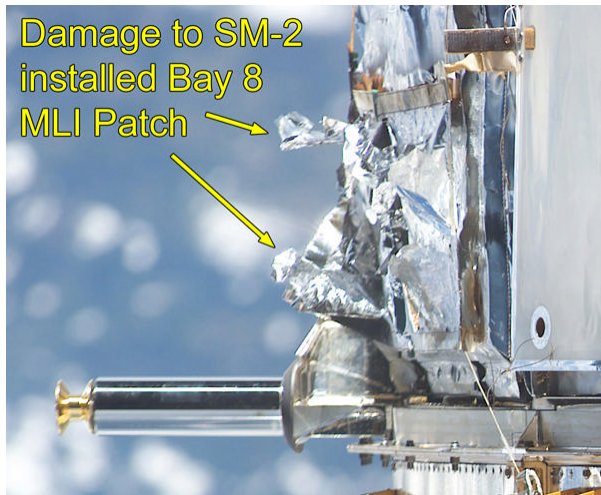
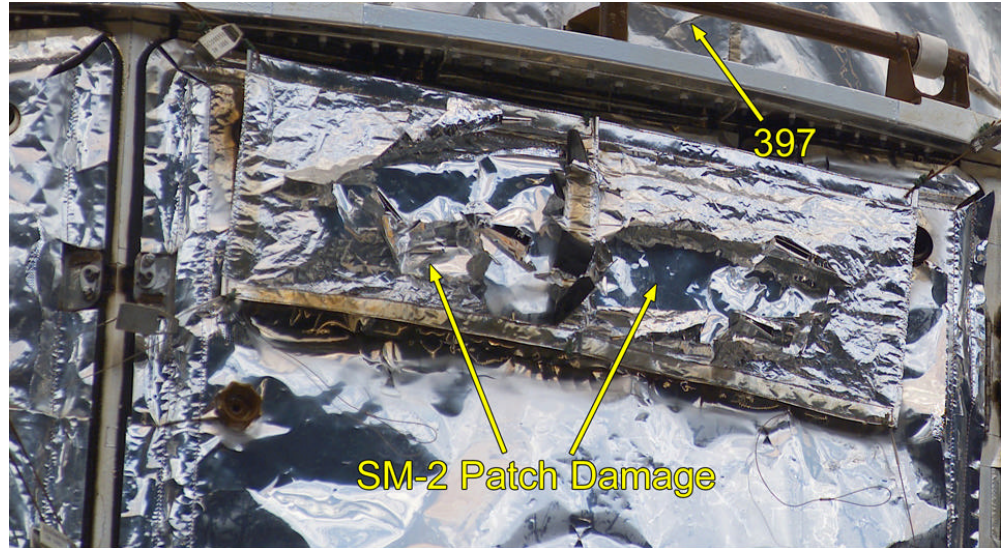
SM-3A



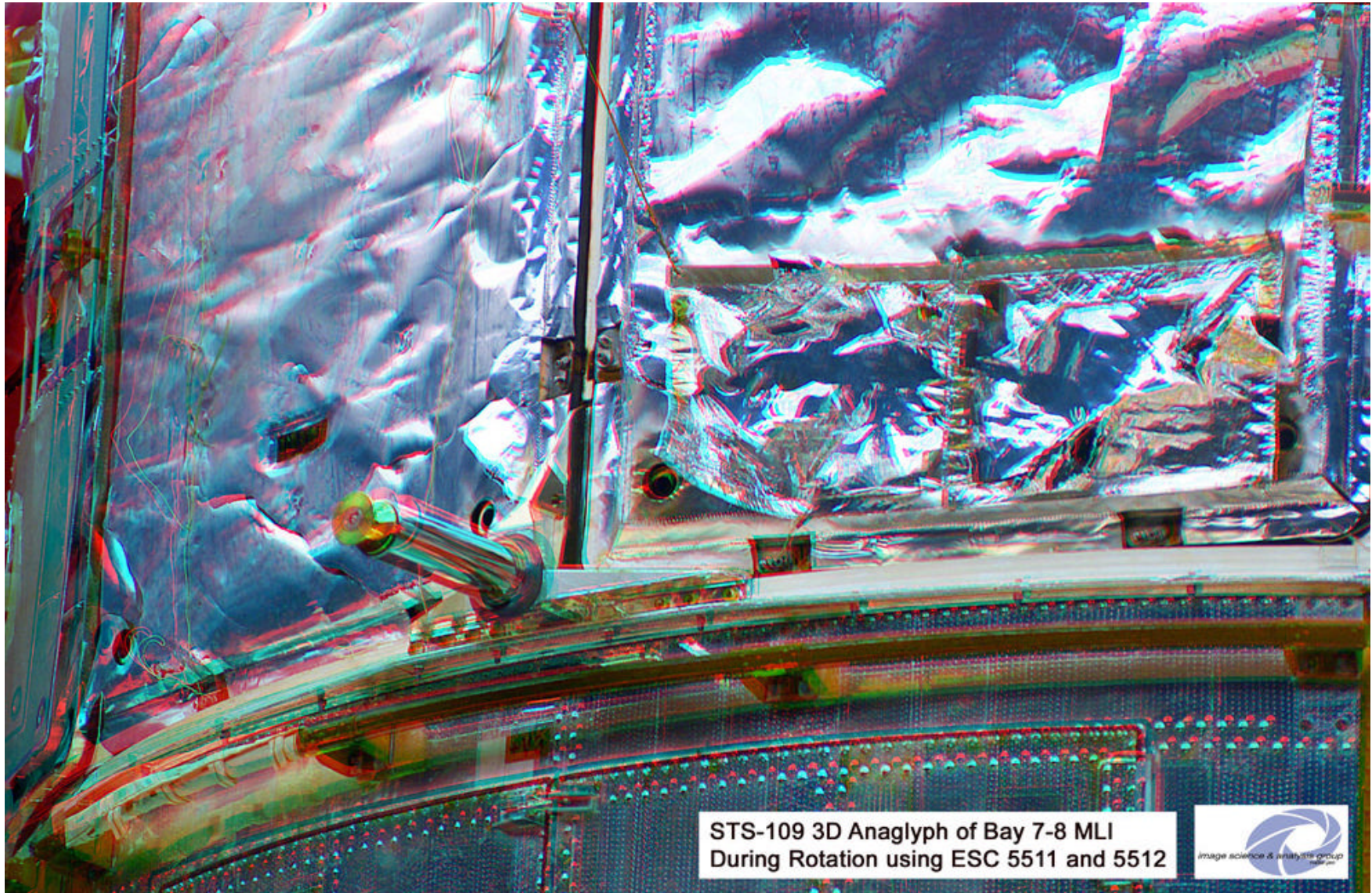
SM-3B



MLI Patch damage



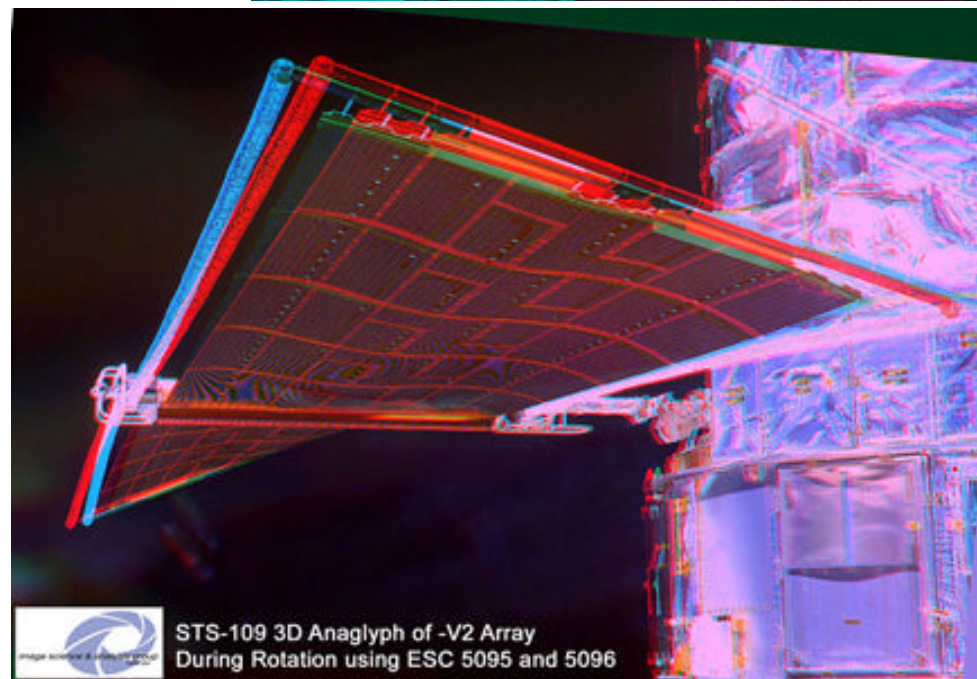
3D Anaglyph from Stereo-type Image Pair



STS-109 3D Anaglyph of Bay 7-8 MLI
During Rotation using ESC 5511 and 5512



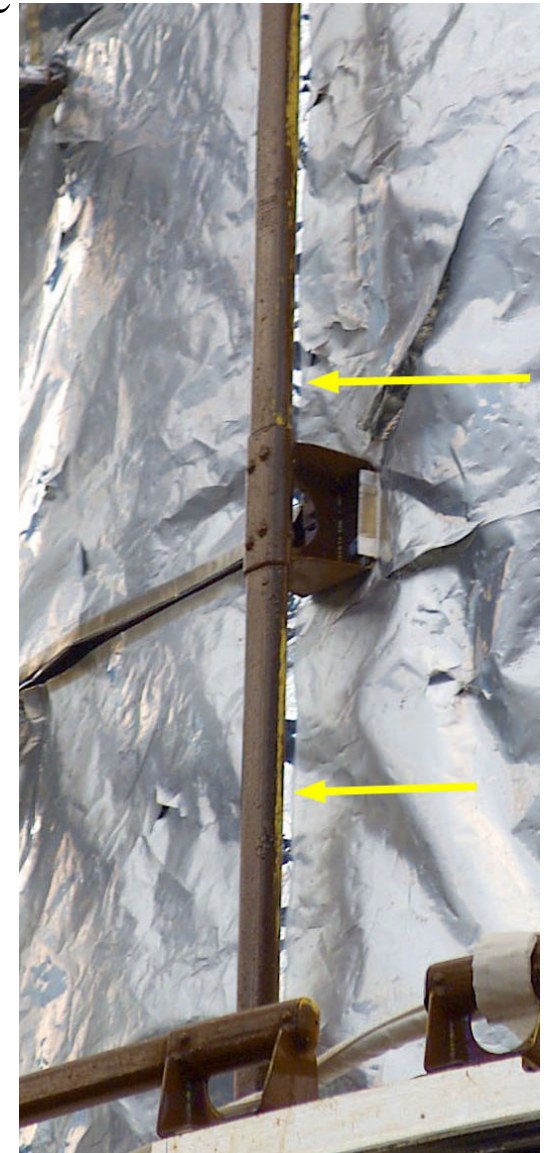
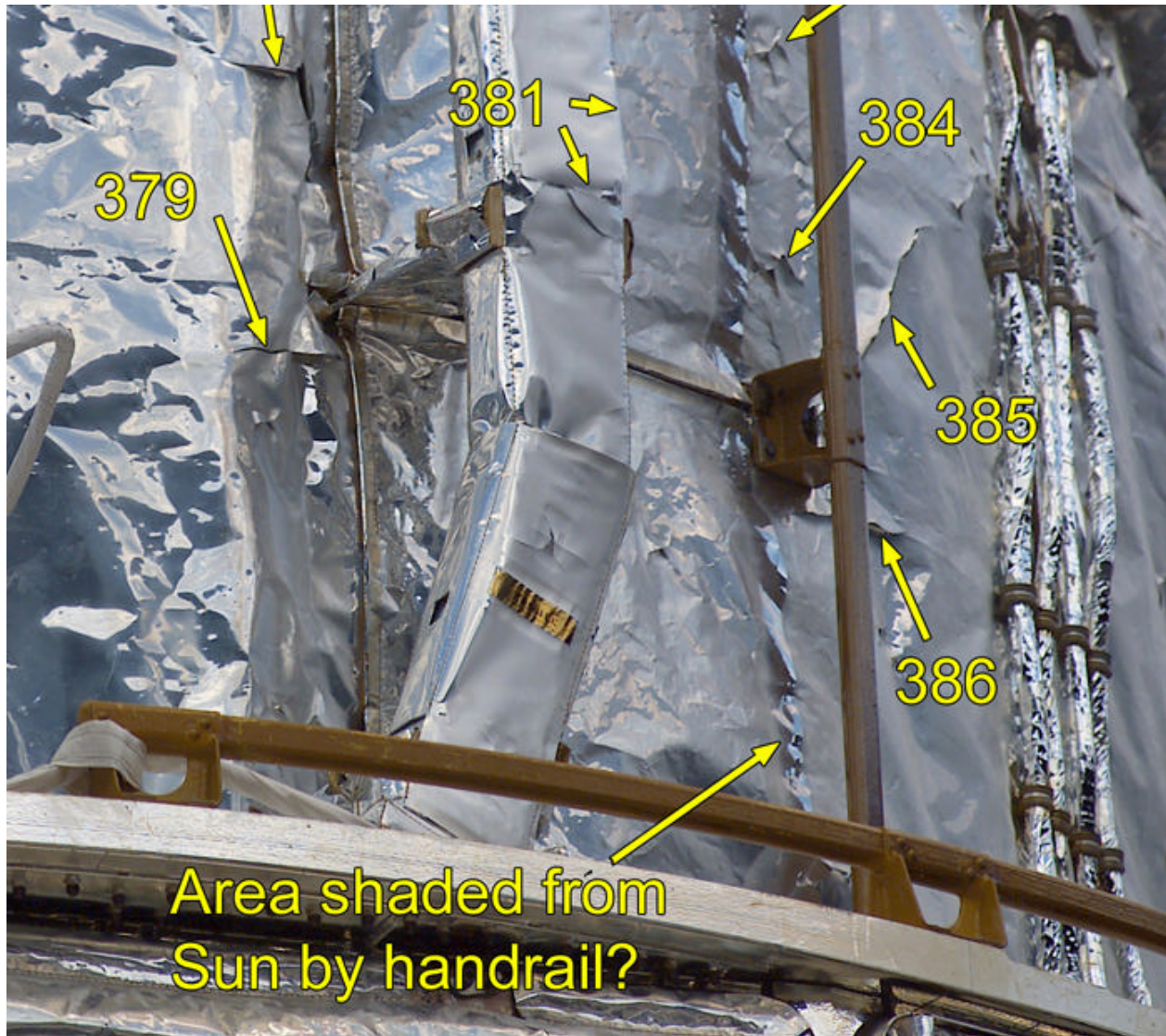
More 3D Anaglyphs from Stereo-type image pairs



Sun Shaded area of MLI?

More likely a plume contamination causes haziness over time

From +V3 fwd



SM-3B Reboost

HST Motion Analysis (HMA)

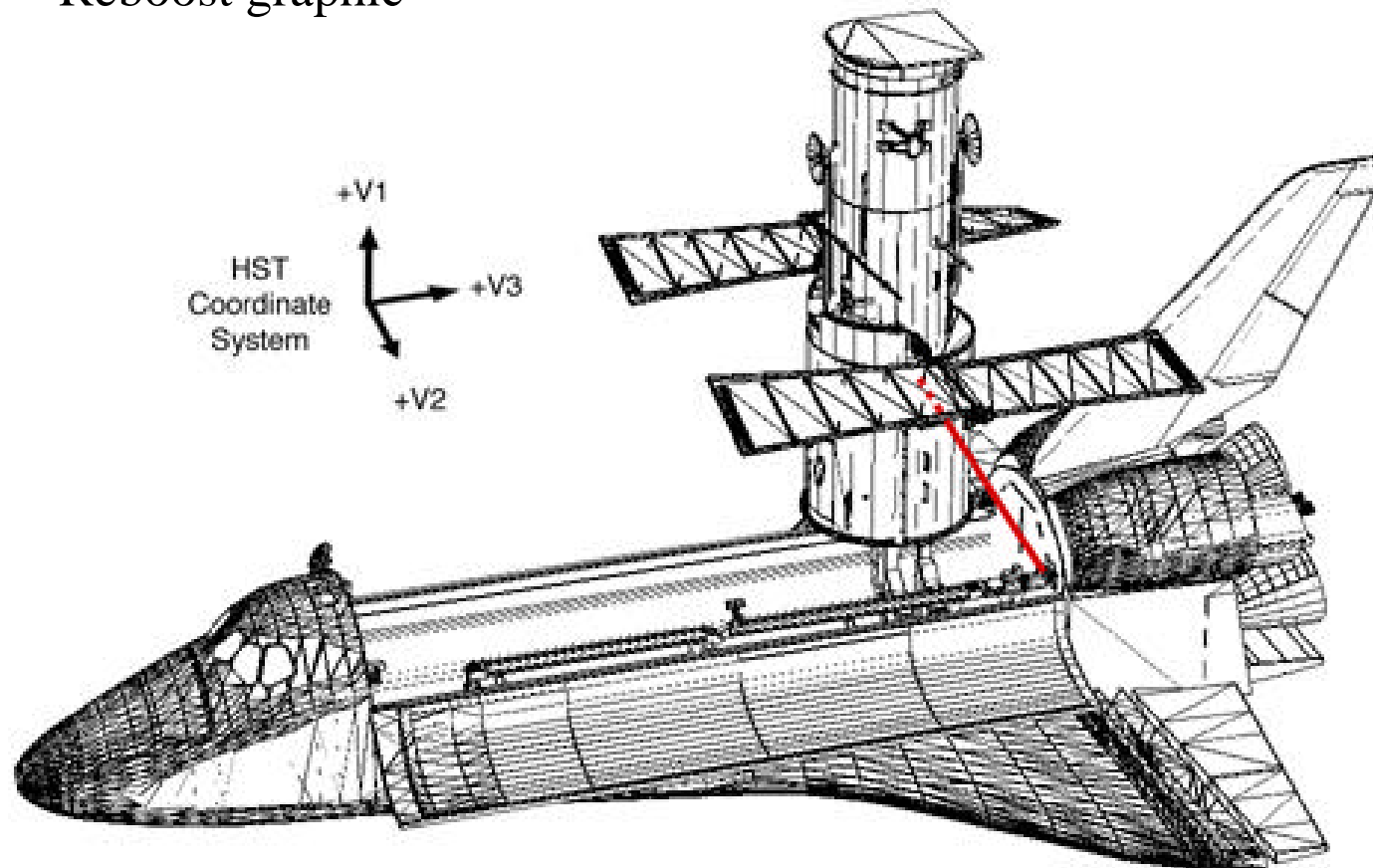
in four easy steps

1. Use HST coordinates + FSS position + Camera position to determine viewing geometry.
2. Use HFOV + Geometry + Pivot direction to determine scale in motion direction.
3. Track the 2D motion; isolate the 1D pivot motion; scale to inches.
4. Oh, and don't forget to tell the crew to videotape the onboard GMT clock before and after!!!

Reboost Scenarios

FSS Rot	Pivot	Camera	Target	tilt	Camera to target			Adjust Scale
					dX	dY	dZ	
-V3 fwd	90	B	+V2 trunnion	50.14	-158.8	-10.75	190.594	0.075
-V3 fwd	90	C	-V2 trunnion	50.14	-158.8	10.75	190.594	0.075
+V3 fwd	90	B	+V2 trunnion	55.45	-130.8	-10.75	190.594	0.0727
+V3 fwd	90	C	+V2 trunnion	55.45	-130.8	10.75	190.594	0.0727
-V2 fwd	90	C	+V3 keel fitting	52.67	-144.8	12.36	190.594	0.0738
+V2 fwd	90	B	+V3 keel fitting	52.67	-144.8	-12.36	190.594	0.0738

Reboost graphic



Red line is B camera sighting the +V2 trunnion

HFOV_deg = 10

Initial Angles	Degrees	Radians
Pivot	90.00	1.57
Rotation	0.00	0.00
Scale	Degrees	Radians
HFOV	10.00	0.17
Image Width	640	Pixels

User Inputs are in Yellow

The camera locations are fixed. All transformations and rotations are done in the Orbital Coord. System (X,Y,Z)

Initial Target Position	V1	V2	V3	X	Y	Z	Camera Position	X	Y	Z	FSS Pivot	X	Y	Z
+V2 Trunnion	240.00	97.75	-14.00	1135.20	-97.75	636.59	A	589.00	-71.50	446.00	Hubble Origin	1177.20	0.00	475.00
-V2 Trunnion	240.00	-97.75	-14.00	1135.20	97.75	636.59	B	1294.00	-87.00	446.00	Diff: Piv-Orig	1149.20	0.00	396.59
+V3 Keel Fitting	240.00	0.00	99.36	1248.56	0.00	636.59	C	1294.00	87.00	446.00				
							D	589.00	71.50	446.00				
							Elbow - Park	766.00	-218.00	688.00				
							Elbow - TBD							

Translation	Rotation	Translation	Pivot	Translation
HST Origin to OCS Origin	ST Rot. about OCS Origin	OCS Origin to FSS Pivot	SS Pivot about OCS Y Ax	Attach to FSS
X Y Z	X Y Z	X Y Z	X Y Z	X Y Z
+V2 Trunnion				
1135.20 -97.75 636.59	-14.00 -97.75 240.00	-42.00 -97.75 161.59	-42.00 -97.75 161.59	1135.20 -97.75 636.59

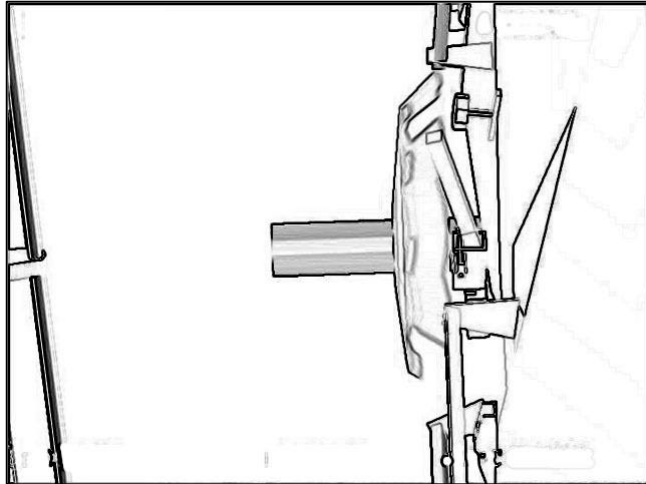
X	Y	Z	R	Scale (HFOV)	Dot Product	3D Foreshortening Angle	Adjusted Scale	Vert. Look (Tilt)	Radians	Degrees
+V2 Trunnion" Final	1135.20	-97.75	636.59	0.0679	-105.749	2.01	0.0750	50.14		
"Camera B"	1294.00	-87.00	446.00							
Camera to Target	-158.80	-10.75	190.59							
FSS Pivot	1177.20	0.00	475.00							
FSS Pivot to Target	-42.00	-97.75	161.59	R in X-Z						
Unit Vector	0.968	0.000	0.252	166.96						

How it works:

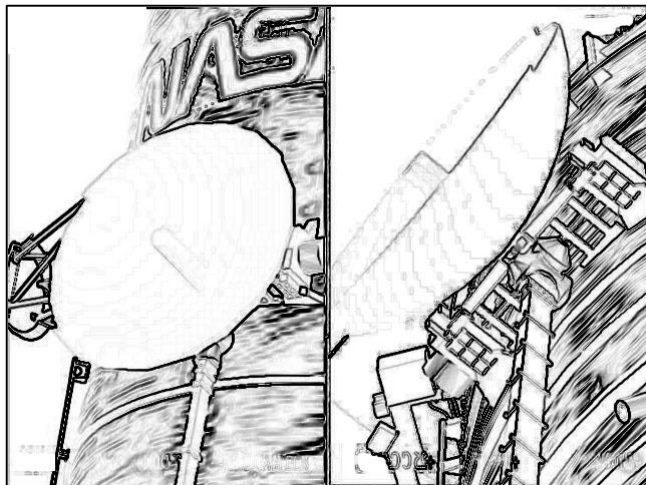
- 1) move the Hubble origin to the OCS origin
- 2) rotate the HST about the OCS origin **ROTATION**
- 3) move the OCS origin to the FSS pivot
- 4) rotate about the FSS pivot location (around the Y in OCS coords) **PIVOT**
- 5) return the HST (in X,Y,Z) to the FSS attach

Reboost Acquisition Plan

Original plan in P/TV chklst

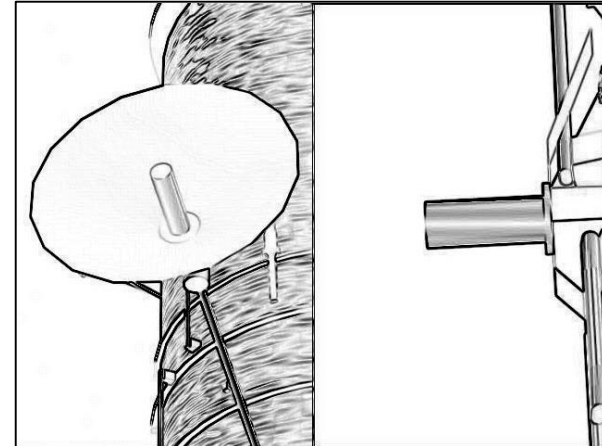


B cam: record + downlink



ELB, C mux: record

Replan



A: Fwd HGA
PAN: -14
TILT: 41
HFOV: 15

B: Port Trunnion
PAN: -4.2
TILT: 50
HFOV: 10

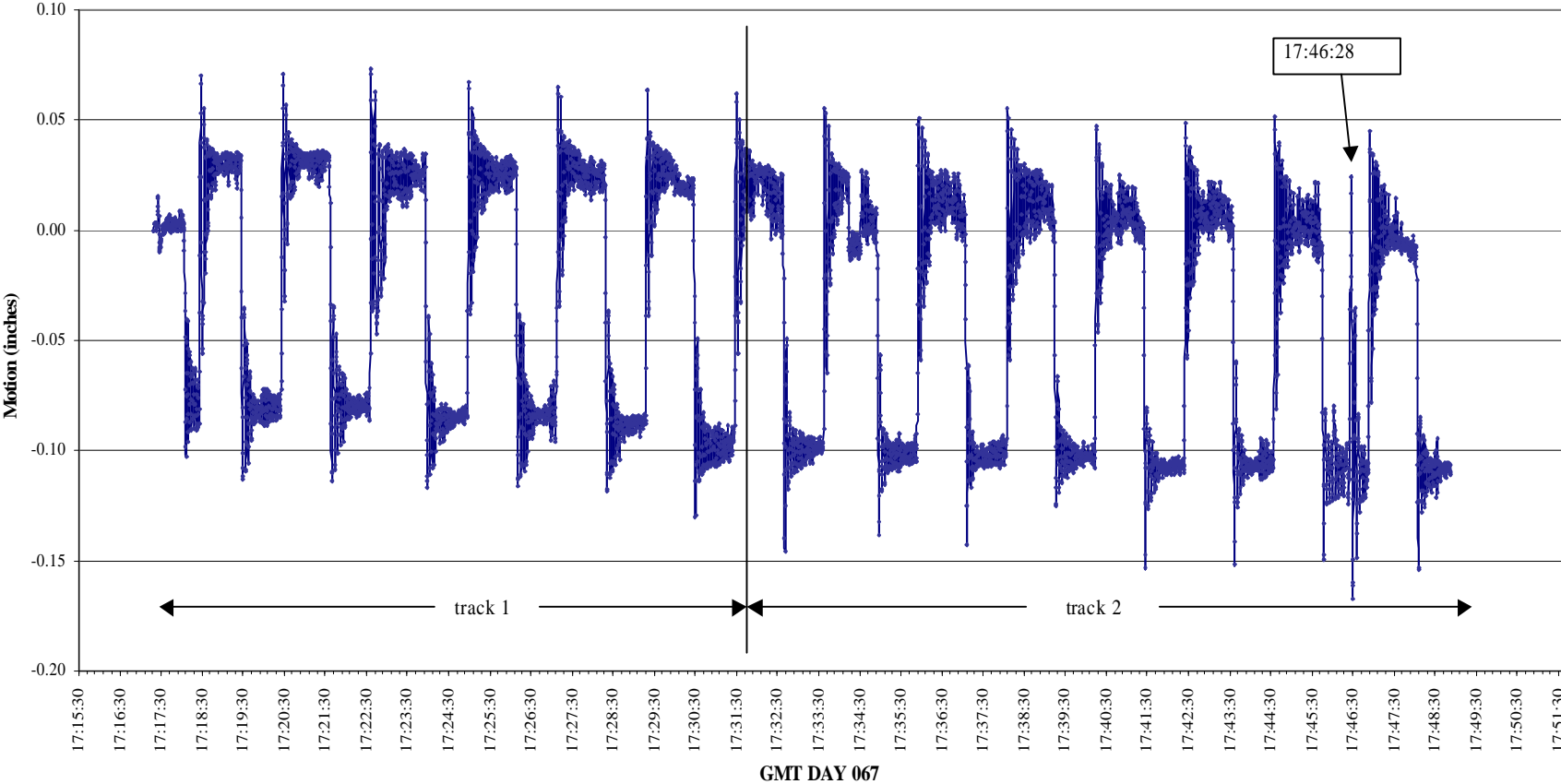
A, B mux: record + downlink

What we got...post-mission



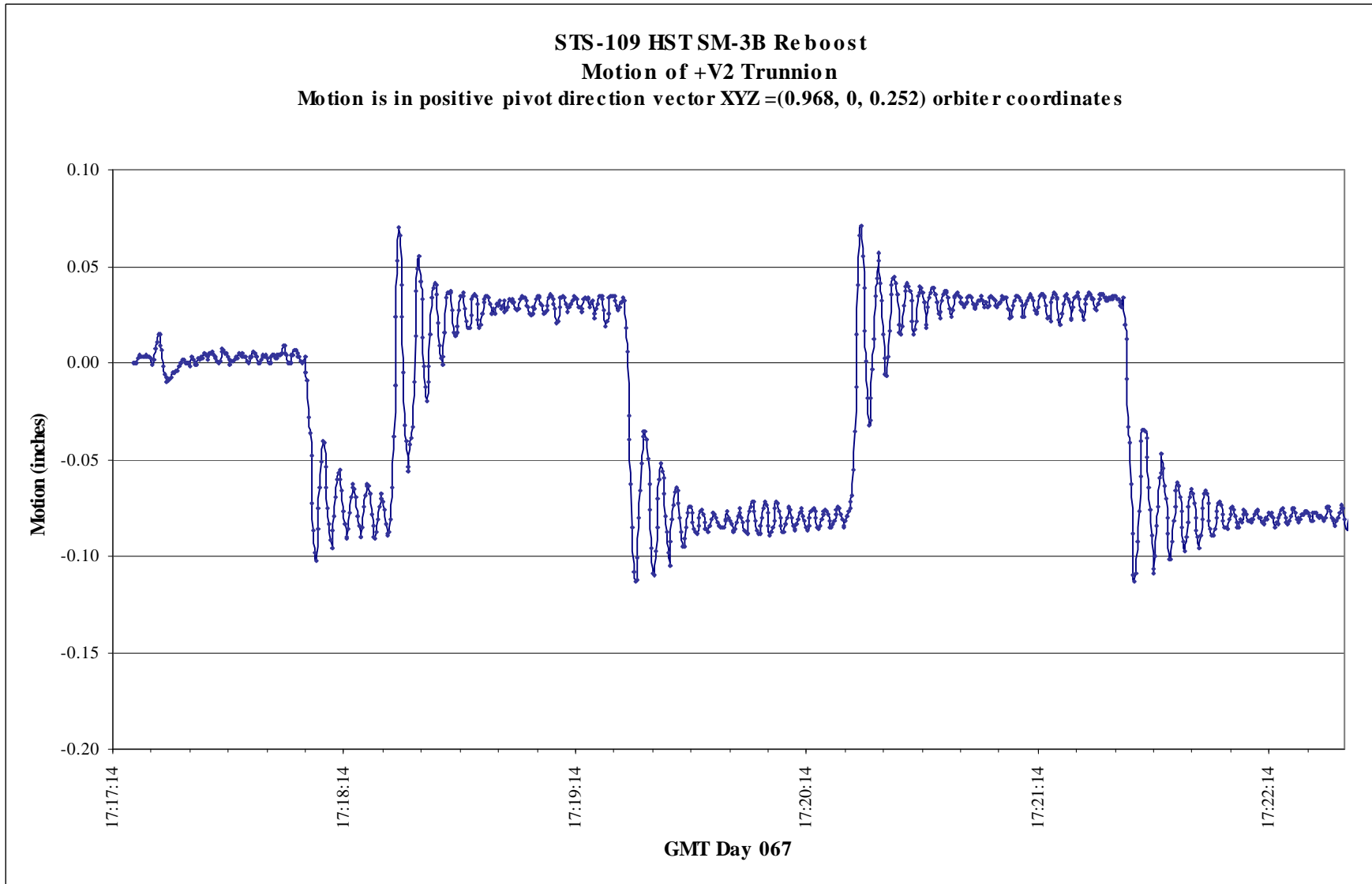
Reboost 1st Analysis on two movies

STS-109 HST SM-3B Reboost
Motion of +V2 Trunnion
Motion is in positive pivot direction XYZ=(0.968, 0, 0.252) orbiter coordinates



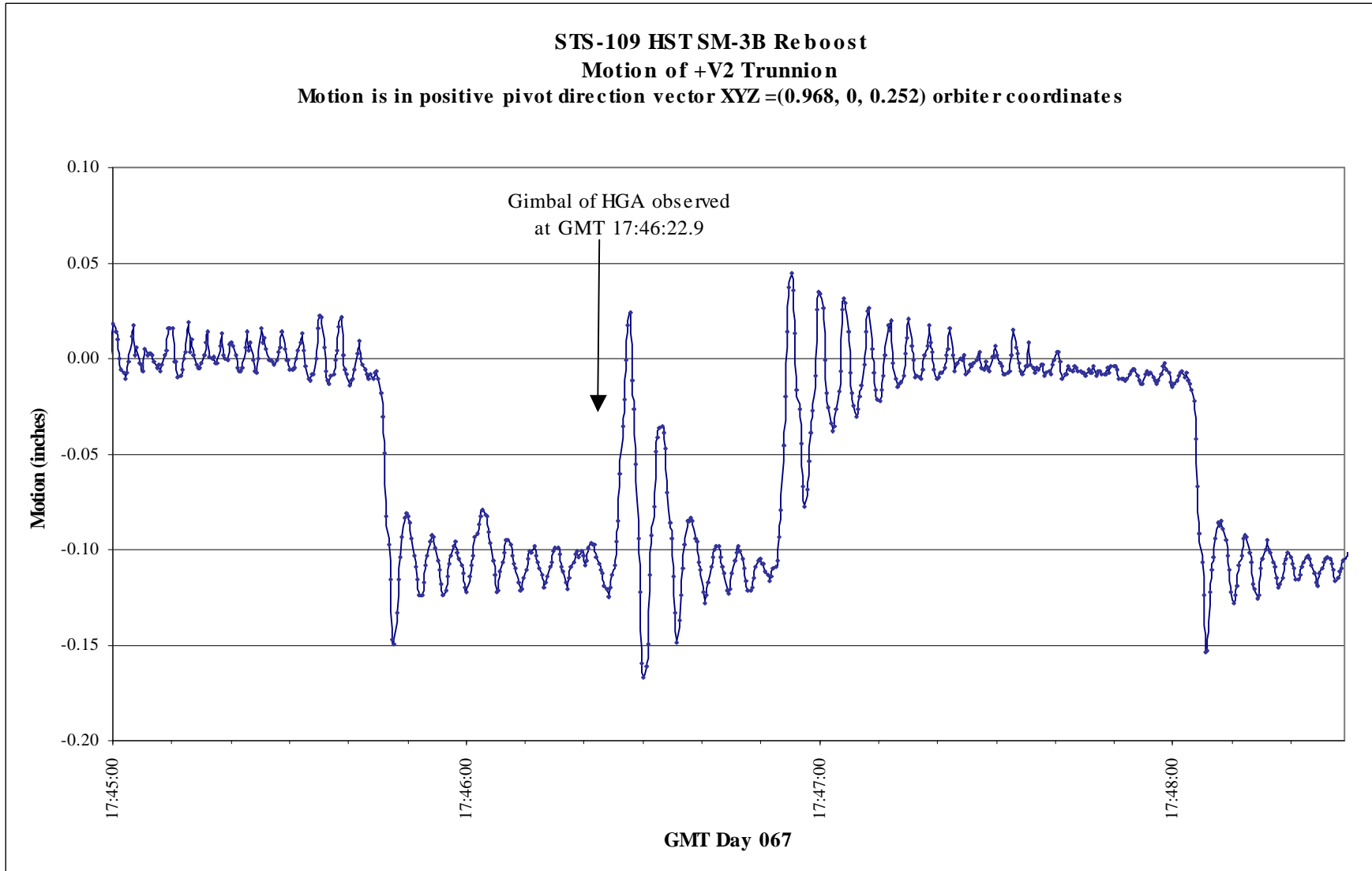
Hst Reboost Motion in the first 5 minutes

STS-109 HST SM-3B Reboost
Motion of +V2 Trunnion
Motion is in positive pivot direction vector XYZ=(0.968, 0, 0.252) orbiter coordinates



HST Motion during Gimbal Event (water dump)

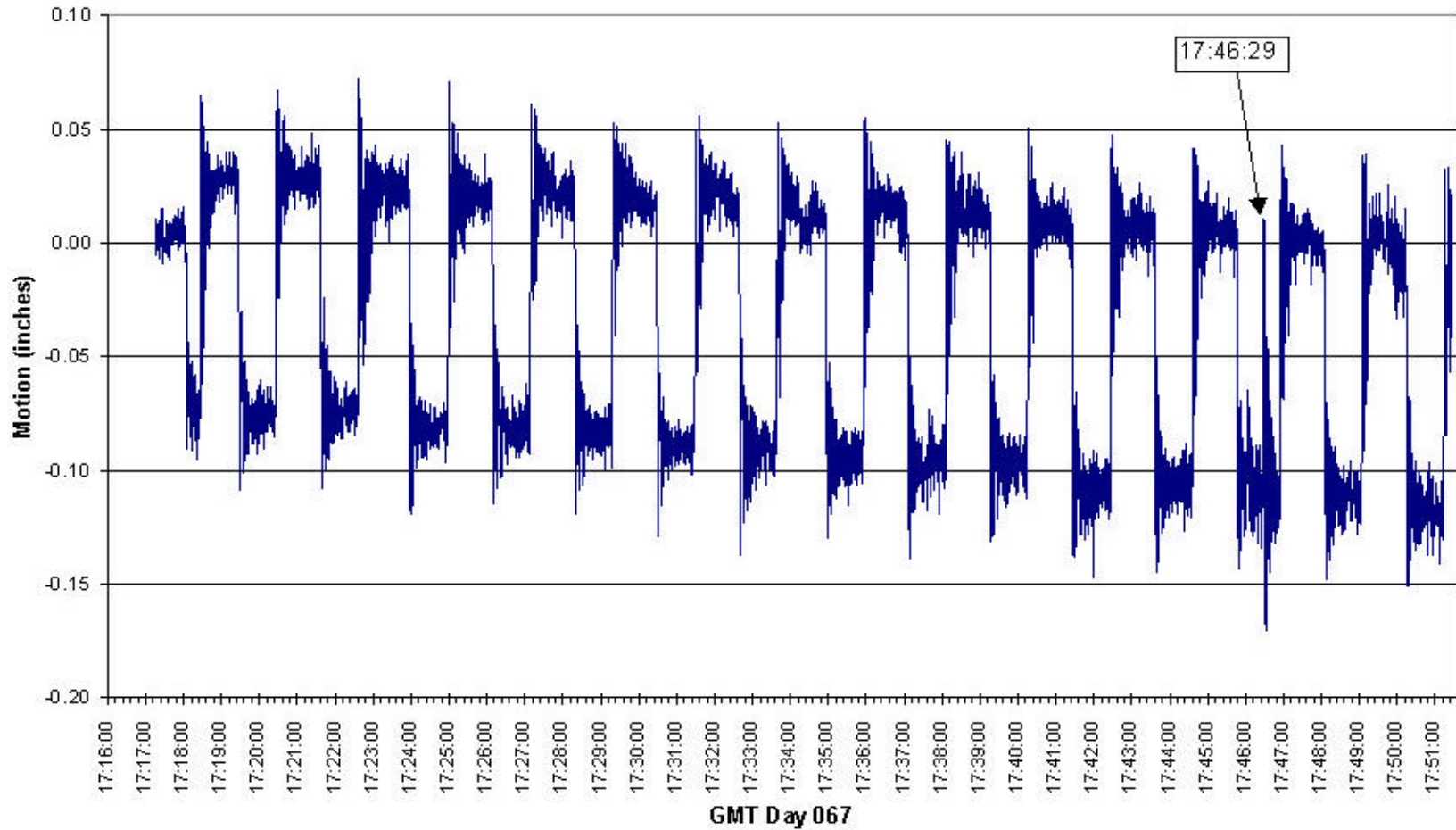
STS-109 HST SM-3B Reboost
Motion of +V2 Trunnion
Motion is in positive pivot direction vector XYZ=(0.968, 0, 0.252) orbiter coordinates



STS-109 HST SM-3B Reboost

Motion of +V2 Trunnion. Analysis is from a single continuous movie.

Motion is in positive pivot direction vector XYZ = (0.968, 0, 0.252) orbiter coordinates.

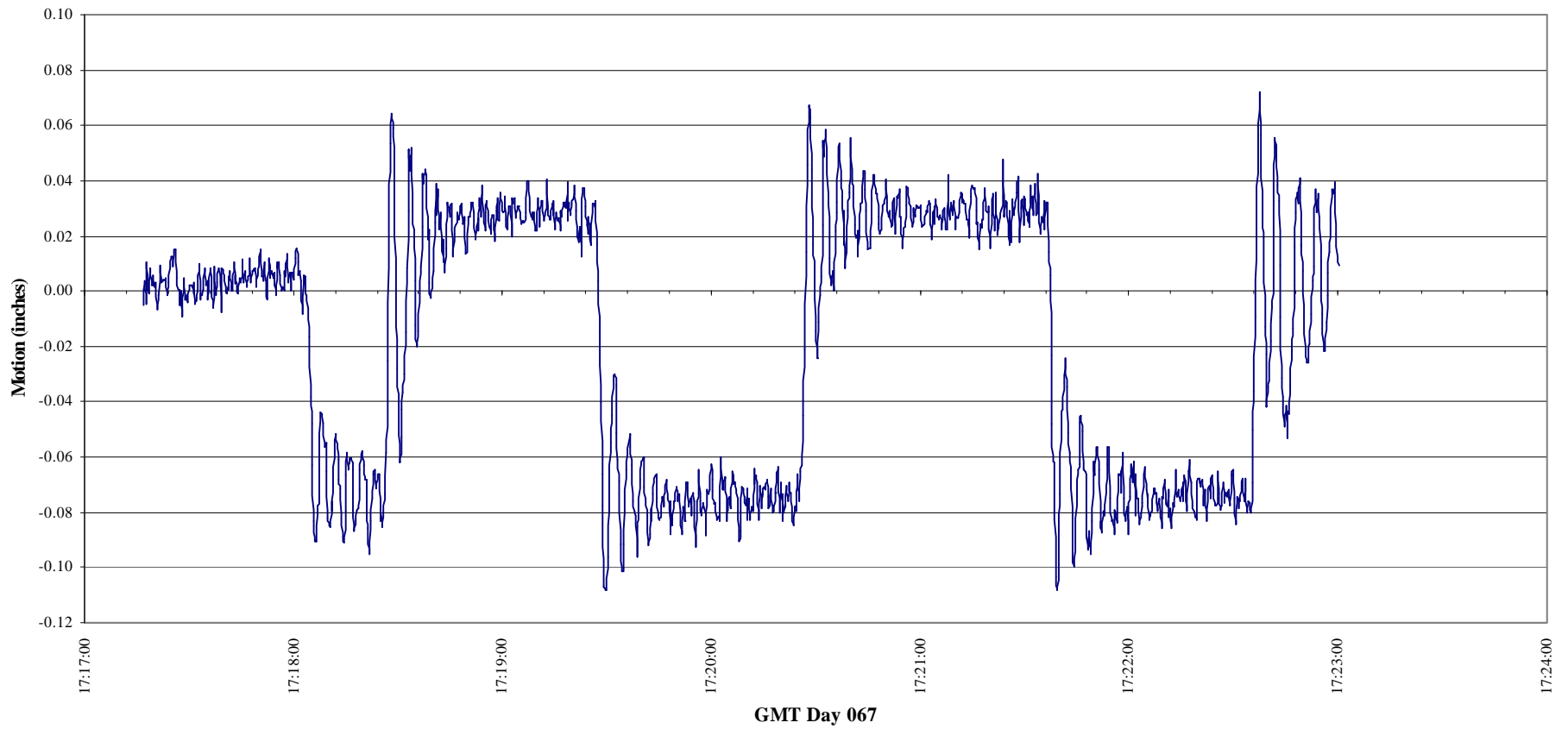


HST Reboost Motion in the first 5 minutes

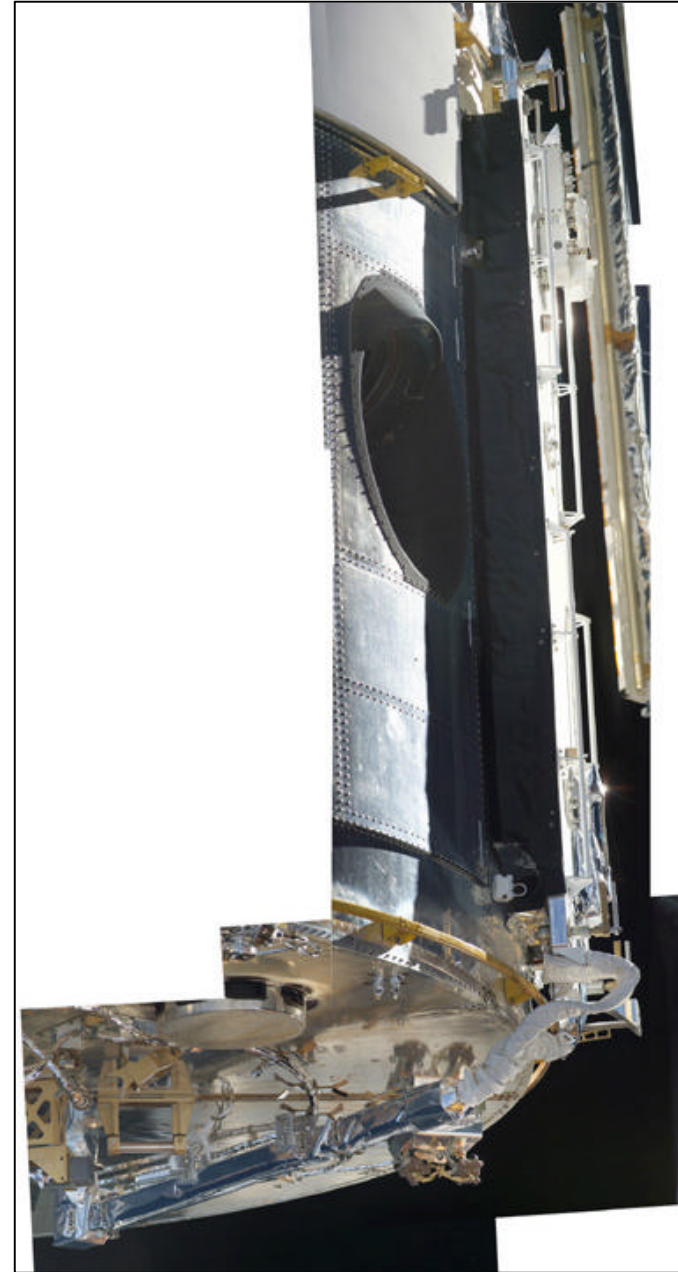
More compressed movie

More noisy tracking

STS-109 HST SM-3B Reboost
Motion of +V2 Trunnion. Analysis is from a single continuous movie.
Motion is in positive pivot direction XYZ=(0.968, 0, 0.252) orbiter coordinates.
First 5 minutes



NCS
Radiator
Surveys



NCS handrail close-up

